# INDUSTRY STUDIES REPORT

(1)



INDUSTRIAL COLLEGE OF THE ARMED FORCES

INDUSTRIA ET DEFENSIO INSEPARABILES





# 1992 - 1993

**NATIONAL DEFENSE UNIVERSITY**
**INDUSTRIAL COLLEGE OF THE ARMED FORCES**
**WASHINGTON, D. C. 20319-6000**

**REPLY TO**
**ATTENTION OF :**

# ACQUISITION MANAGEMENT

# INDUSTRY STUDIES

The Industry Studies Program of the Industrial College of the Armed Forces analyzes selected industries to assess their ability to provide the weapons, products, and services that are required both now and in the future. Sixteen committees of students were formed to study industries that play major roles in defense production. Each committee investigated a vital industry and analyzed its composition, structure, operations, management techniques, economic health, business objectives and strategies, and its current trends and problems. From this survey, an assessment was made of the ability of the industry as a whole to meet the requirements of a national mobilization and its state of readiness to surge production for the armed forces.

During the course of its study, each committee interviewed leaders of its industry, held seminars with supporters and critics, conducted individual research, traveled to domestic and foreign industry plants and facilities, and drew heavily upon the experience of the members. The written report of each committee follows this introduction. Taken together, these assessments give a topical look at the industrial mobilization base of the United States as it exists, a view of the world-wide industrial base and provide a summary view of the major problems faced by the industries we consider to be crucial to the defense of the nation.

Suggestions for other areas of study are earnestly solicited and should directed to the undersigned.

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Gerald W. Abbott
Director
Industry Studies Program

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# INDUSTRY STUDY SUMMARIES

## ACADEMIC YEAR 1992-1993

INDUSTRIAL COLLEGE OF THE ARMED FORCES

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## PLACES VISITED

### Domestic

| | |
|---|---|
| Smithsonian Institution | Washington, DC |
| Association for Manufacturing Technology | McLean, VA |
| Wayne State University | Detroit, MI |
| General Motors Cadillac Plant | Detroit, MI |
| South Carolina Research Authority | Charleston, SC |
| General Dynamics Land Systems Division | Lima, OH |
| Aeronautical Systems Center/ENM | WPAFB, OH |
| Toyota Camry Plant | Georgetown, KY |
| General Electric Aircraft Engine Plant | Evendale, OH |
| Mazak Corporation | Florence, KY |
| Cincinnati Milacron | |
| Plastics Machinery Division | Mt. Orab, OH |
| Corporate Headquarters | Oakley, OH |
| Air Force Material Command/XR | WPAFB, OH |
| Westinghouse | Baltimore, MD |

### International

| | |
|---|---|
| Goldstar | Pyongtaek, Korea |
| DaeWoo Heavy Industries and Motor Company | Inchon, Korea |
| UNC/CFC Headquarters | Seoul, Korea |
| U.S. Consulate General | Hong Kong |
| Secretariat, Director General of Industry | Hong Kong |
| Hong Kong Shanghai Bank | Hong Kong |
| Guangdong Province | PRC |
| American Chamber of Commerce | Hong Kong |
| Hong Kong Productivity Center | Hong Kong |
| Philips Consumer Electronics Factory | Hong Kong |
| FANUC | Oshino-mura,Japan |
| NKK Keihin Works | Kawasaki, Japan |
| Nissan Motor Company | Oppama, Japan |
| Toshiba Fuchu Works | Tokyo, Japan |

## INTRODUCTION

The domestic U.S. manufacturing base is critical to our long term national security. The automated manufacturing industry study group logged over 500,000 miles and traveled to 28 locations, 6 states and 4 foreign countries to evaluate worldwide manufacturing trends. Our primary objectives were to analyze the health of the industry and to provide a status report. We also developed a set of policy recommendations to improve the nation's capability to produce technologically superior weapon systems at an affordable cost.

Over the past quarter century, industrial economies have increasingly exploited information technologies--computers and telecommunications equipment--to gain global competitive advantage. In the non-defense or commercial manufacturing sector, this trend has led to greater use of automated manufacturing techniques and processes. To capture this broader essence of "manufacturing", our industry study group chose to define the terms "Automated Manufacturing" as the flexible use of people, machines and computers to design, make or assemble goods.

Factory automation uses computer-integrated manufacturing (CIM) technology to link factory floor operations with the rest of the production enterprise. The benefits associated with CIM and other advanced manufacturing technologies (AMTs) can be enormous. For example, distributed numerically controlled (DNC) machine tools allow part machining instructions to be downloaded from a central computer-aided design (CAD) data base. In addition, by organizing six or more DNC machining centers under a master supervisory control with automatic wire guided vehicles (AGVs) we create a flexible manufacturing system (FMS). This system dramatically boosts productivity by halving labor requirements and doubling the use of machine spindles. Automated storage/retrieval systems (AS/RS) and computer-driven material resource planning (MRP) systems boost productivity still further at the plant level.

Our study group observed many failed attempts to automate the manufacturing process. In every case, the firm focused solely upon the acquisition of an advanced manufacturing technology (AMT). These firms paid little attention to the firm's core business practices or its overall production process. Early in our study, the group concluded that decisions regarding the introduction of new manufacturing technologies require a system perspective. We came to view manufacturing technology as just one component of the overall business enterprise striving to produce and deliver a quality product at a competitive price.

In this context, we believe that three integrated elements compose a manufacturing enterprise--manufacturing process technology, the product development system, and the production organization. Manufacturing process technology determines the attainable tolerances, part dimensional repeatability and the expected assembly functional reliability for a given product design. The enterprise's product development system influences the speed, cost, and ease of manufacture to bring a new product to market.

Perhaps the greatest determinant of competitive advantage is the production organization itself. A "lean" producer uses information technologies to cut in-process inventories while improving product quality and reducing indirect/direct labor ratios. Flexibility allows "unbuffered" (minimal inventory) plant operations and material flows. Ultimately, information technologies to link geo-

graphically separated production facilities in a "virtual" enterprise or "agile manufacturing" organization improves the entire business enterprise. Clearly, a "world class" manufacturing enterprise must carefully orchestrate all three production elements.

This report presents a summary of the automated manufacturing industry study group's observations, findings, and recommendations. We begin by describing the structure and competititive strategies of the automated manufacturing industry. Next, we explore the recent trends and the long-term outlook for the industry. We present a framework for benchmarking a manufacturer's progress towards producing high value goods. Then, we examine three key defense issues--weapon system affordability, technological superiority and reconstitution strategy. We conclude by providing several policy recommendations for an overall U.S. industrial policy.

## STRUCTURE

Though not a traditional or precisely defined industry, the U.S. automated manufacturing industry includes three distinct sectors. The first sector, the capital goods sector, consists of those corporations who furnish automated manufacturing capital equipment and services. The second sector, the heavy industry sector, is the major end item market for producers of automated manufacturing equipment and systems. Although automation is increasing in many high labor cost areas, the third sector, light manufacturing, remains predominantly labor intensive. Our industry study group believes it is important to examine the structure and performance of these sectors in order to gain a good overall perspective of the state of automated manufacturing in the world today.

### Capital Goods

The suppliers of automated manufacturing equipment and services constitute a strategic industry group. This includes producers of computer numerically controlled (CNC) machine tools that hold precise tolerances at high speeds, reliable robotic welders and a host of other capital equipment that incorporate the latest advanced manufacturing technologies (AMTs). This sector builds the machines that manufacture the durable goods our industrial society consumes. This sector also produces the precision machines required to produce other manufacturing tooling and equipment. From this viewpoint, this sector is the "mother industry."

Without a strong "mother industry" a nation soon loses its competitive advantage in manufacturing. When equipment is not available within a reasonable length of time or at an affordable price through domestic suppliers, American manufacturers will obtain these items--the means of production--from foreign sources. Typically, the exporting country will have had access to the same leading edge equipment for one or two years before permitting export. Under these conditions, it is difficult, if not impossible, for a nation to be an industry leader without a strong domestic machine tool industry.

A two-tiered supplier structure supports American machine tool companies. The first tier is the component supplier base. Core competencies in these firms tend to concentrate in a specific discipline or area--mechanical, electronic or telecommunications. The product lines range from cutting tools and metal forming dies to electronic controls for industrial robots. The second tier suppliers combine these specific manufacturing technologies and deliver equipment and services at

one of four levels of integration: (1) the individual workstation, (2) the multi-machine work cell, (3) the plant, or (4) the overall business enterprise.

Although there are no systematic aggregate indicators to measure overall performance of the "Automated Manufacturing" capital goods sector, we will focus on three industry groups: (1) computer-aided design, manufacturing and engineering equipment and software, (2) machine tools, and (3) robotics.

### CAD/CAM/CAE Equipment and Software

An Automation Forum survey indicated U.S. industries spent nearly $33 billion on automation investment in 1989. Companies invested primarily in computer-aided design (CAD), computer-aided manufacturing (CAM), and computer-aided engineering (CAE) hardware and software, plant operations software, production equipment, and automatic materials handling equipment.[1]

CAD/CAM/CAE software allows the design, engineering, and manufacturing of products such as aircraft, automobiles, and consumer goods. In 1992, the market for this software grew less than 1 percent from 1991, with U.S. revenues at $557 million. This slight growth is a direct result of changing budget allocations and high levels of market penetration. Internationally, the sluggish world economies affect the slow growth of the CAD/CAM/CAE markets. The lack of industry standards also forms a barrier to entry, since users are reluctant to adopt the newest technologies.

### Machine Tools

In the manufacturing process, machine tools cut or form metals. Machine tool production has been slow for the past several years in the U.S. Since 1978, foreign market penetration has resulted in U.S. imports exceeding exports. U.S. manufacturers have been slower than our competitors to integrate computer controls into machine tools, a key factor in leading to the significant Japanese imports to the U.S. In 1982, imported numerically controlled machines comprised 35.5% of the U.S. market ($547.8 million). In 1984, imports exceeded 50% ($661.3 million) and this level has remained above 50% to the present.

The U.S. consumes a wide range of automated machine tools, including machining centers, lathes, boring machines, milling machines, gear cutters, grinders, and laser and thermal cutting machines. In 1990, the U.S. shipped about $1.4 billion/7,927 units, imported $1.2 billion/11,278 units, and exported $.4 billion/2,697 units in numerically controlled equipment for a total U.S. consumption of $2.2 billion/16,508 units.[2]

### Robotics

The robotics industry dates back to the invention of the technology in the U.S. in the 1950's. Today there are only six companies that manufacture robots in the U.S. and only one of them sells internationally. Hundreds of companies, however, provide accessory equipment, serve as systems integrators, or distribute robots built overseas.

Japan is the leading producer and the largest user of robots. In 1991 Japan had 325,000

robots in use as compared to 44,000 in the U.S. and 55,200 in Europe. The automotive industry is the largest user of robotics in the U.S. and Japan. Normal applications are spot welding, materials handling, assembly, and painting and coating. Recently, there has been growth in non-automotive applications such as electronics, food packaging, appliance, and pharmaceutical industries.

Europe invests $1.5 billion annually in industrial robotic systems and will spend $20 billion on robotic R&D over the next few years, whereas the U.S. invested only $400 million in robotic systems. West Germany and Japan spent two percent of their GNP on non-defense R&D in 1977 while the U.S. spent only 1.5%. In 1987 Japan spent 3%, West Germany spent 2.5% and the U.S. spent only 2%.

U.S. robotics companies are receiving $400 to $500 million worth of orders annually, though they only have less than 3 percent of the world market. The industry is looking for an overall growth of 7 percent in 1993. This optimistic outlook assumes: (1) companies that have been putting off large capital equipment expenditures will no longer be able to delay them, (2) growing pressure on U.S. companies to improve productivity and quality will lead to more automation, and (3) increasing use of robots in the Pacific Rim and Europe will open new export markets.

The long-term market potential for the U.S. robotics industry is promising. The North American market remains untapped. Analysts believe that less than 5 percent of the companies that could benefit from robots have installed them. There are also a growing number of start up firms developing new robotic applications outside the factory. The so-called "service robot" industry is now emerging, featuring robots for health care, security, nuclear clean-up, space exploration, and commercial clean-up. At present the U.S. has a slight lead in this new industry but will have to produce and market these robots before the Japanese.

Although the U.S. struggles to compete in industrial robot manufacturing, domestic companies are very competitive in areas such as vision guidance for robots, robot programming and control, and robot sensors. U.S. companies are also strong players in systems integration, a rapidly growing field, for user businesses that increasingly are seeking automated solutions. The key to competitiveness will be the ability of U.S. firms to go from R&D to production and marketing before its overseas competitors.

**Heavy and Light Manufacturing**

Suppliers of automated manufacturing equipment and services depend heavily upon the investment patterns of their customers and the health of the economy for their well-being. Capital goods suppliers tend to be among the first to be affected by a downturn in the economy and among the last to feel the effects of a recovery. However, it is the investment practices of their heavy industry customers that have a major impact on the strength and survival of this industry. In some regions, traditionally labor intensive light manufacturing operations are becoming more automated. The group observed that these firms tend to develop their own automated equipment and processes.

## COMPETITION STRATEGIES

An increasing level of globally based competition has confronted manufacturers over the past 50 years. U.S. manufacturers responded to this challenge in three successive stages. The first response was to cut manufacturing costs by shifting production operations to low labor cost areas. Firms relocated from the Northeast portion of the country to the "Sunbelt" states in the South and Southwest. In later years, this strategy forced operations to move offshore to newly industrialized countries.

During our travel to the Orient, we observed the manufacture of Zenith VCRs at Goldstar in Korea and Magnavox audio electronics at Philips in Hong Kong. In recent years, we observed evidence of a second migration in search of low labor costs. Many Korean firms are entering into joint ventures with corporations in Central and South American countries. Hong Kong's industrialists have shifted a significant portion of their manufacturing operations to Guangdong Province in southern China and Viet Nam. At present, manufacturing (mostly light) accounts for only 17% of the Hong Kong economy. This new migration is being fueled by rising wages and standards of living.

There is evidence that manufacturers in these countries as well as the U.S., Europe and Japan have countered with a second competitive strategy--improve product quality through factory automation. Automation also led to higher productivity and lower overall cost in many cases. The initial implementation of this strategy began with substantial investment in rigid processes and capital investment. This strategy appeared to work as long as long life cycle production runs allowed spreading these costs over high volume. This makes the most sense in heavy industries rather than light manufacturing operations. We saw evidence of certain heavy industries moving back to the United States. Caterpillar and General Motors terminated their joint ventures with DaeWoo for production in Korea.

We now perceive the emergence of yet another competitive strategy--increase product value. In this sense, high value products require manufacturers to deliver a technology intensive item at low cost, high quality and tailored to the customer's needs. More often than not, this task requires high wage labor and flexible automation. Increasingly fragmented and heterogeneous markets drive this strategy. It exploits a new source of competitive advantage: the ability to respond to niche markets with sharply differentiated and short life cycle products. A corporation that is pursuing this strategy will employ about 30-40% of its total workforce in research & development activities. During our international travel, we observed that two Japanese corporations--FANUC and Toshiba--have adopted this strategy.

## TRENDS

All three strategies are in use today in different industries and in different countries. This will continue to be the case in 20 years. However, by the end of the 21st century, it is difficult to imagine successful pursuit of a manufacturing strategy other than to produce high value products. We believe that the demand for low tech products will disappear in the face of comparably priced high tech alternatives. The task for the U.S. manufacturing sector, as well as the other industrialized countries of the first world, is to move to a high value product strategy as quickly as possible.

To do this, current revenues from existing product lines must finance long term investments in multi-skilled human resources, capital intensive automation and flexible manufacturing processes. The transition to an economy based upon high value products must not be too sudden or across all industries at once. Defense weapon systems, industrial products and capital goods are technology intensive and well suited to the high value added strategy. The emerging high tech information-based industries--semiconductors, software, computers and telecommunications equipment closely follow these industries. Heavy industries will transition next. Eventually, rising standards of living across the globe and decreasing wage differentials will force traditionally labor intensive light manufacturing industries to compete in high tech markets.

Our industry study group developed a generic benchmarking tool to evaluate progress towards implementation of the high value product strategy. This tool, shown in Table I, identifies five key innovations that are necessary to boost manufacturing productivity. Each innovation corresponds to a different level of integration within a manufacturing organization or enterprise.

**Table I**
**Automated Manufacturing Trends**
(in the United States)

| Time Period | Innovation | Level of Integration |
|---|---|---|
| 1950-1980 | Advanced Manufacturing Technologies | Workstation |
| 1970-1990 | Computer Integrated Manufacturing | Manufacturing Cell |
| 1980-2000 | Lean Production | Plant |
| 1990-2010 | Agile Manufacturing | Enterprise |
| 2000+ | Custom Order Economy | Industrial Web |

Before we discuss each innovation in detail, it is important to note that the first two innovations--advanced manufacturing technologies and computer integrated manufacturing--are "hard" technologically driven advances. The latter three innovations, although at a higher level of integration, involve "soft" changes in management, organization or culture. In the United States, we first made the "hard" technical advances. This is not always the case in every industry or country. For example, the automobile industry in Japan pioneered lean production methods at Toyota in the mid-1950s before the introduction of CIM technology.

### Advanced Manufacturing Technologies

At the workstation level, we observed a general trend towards employment of advanced manufacturing technologies (AMT) to automate parts fabrication and component assembly opera-

tions. This trend appears to stem from a desire to increase worker productivity and improve product quality. Automation improves product quality by reducing the variability in manufacturing processes. Most of the workstation automation resulted from the fusion of mechanical or motive power with electronics and other information based technologies.

Our analysis revealed that each successive generation of automated equipment is more flexible. This means it is easier and quicker to change the basic functionality of a device or piece of equipment. In the machine tool industry, numerically controlled machine tools were first developed at the Massachusetts Institute of Technology in the 1950s with the introduction of a control language called APT--automatically programmed tools. Although technologically advanced for its time, APT was too sophisticated, rigid and inflexible for broad application across the machine tool industry. The development of the transistor and modern microprocessors led to the widespread use of reprogrammable computer numerically controlled (CNC) machine tools.

More advanced computer technology also gave us the ability to do engineering drawings (and time consuming revisions) on the computer and the ability to do engineering analyses on these designs--computer-aided design (CAD) and engineering (CAE) respectively. Today, systems allow electronic transfer of a computer representation of a design to a computer-aided manufacturing (CAM) data base. Distributed numerically controlled (DNC) machining centers can then receive the data without any reprogramming or intervention by a machine tool operator. In addition, a new AMT--stereolithography--allows the designer to make a plastic model of the part through the use of laser and photosensitive material technologies. Other advances in the machine tool industry will include superior cutting tools (like carbide inserts), dies and electronic controls.

Software is another major AMT area. This is a field dominated by U.S. companies--selling 70 percent of the CAD/CAM/CAE software globally in 1992. Although we are the leader in providing the technology, we are not the leader in using the technology. Currently, Europe is the largest and fastest growing market, accounting for 37% of the global sales, with North America at 34 percent, and Asia at 27 percent.

The major AMT trends in industrial robotics are microprocessor based controls and vision systems. Microprocessors are replacing "hard wired" electronic controls. Vision systems allow robots to compensate for uncontrolled movement of objects and fixtures. FANUC of Japan commands a sizable share of the world industrial robotics market. FANUC has introduced new technology while increasing the standardization and modularization of its product lines.

Unfortunately, U.S. manufacturers of industrial robots have exited the market. Cincinnati Milacron, the U.S.'s largest producer of industrial robots, sold this business to a European firm last year. Much of the problem is due to the short sighted practices and the failure to create market demand by the primary users of industrial robots in the U.S.--Ford, General Motors and Chrysler.

The overall forecast for workstation automation is in the direction of greater flexibility. Information based AMTs make this happen. Manufacturers of industrial capital equipment--machine tools, robots, etc.--will pursue corporate acquisitions that provide a "strategic fit" of core competencies. Although U.S. manufacturers dominate the market for sophisticated and specialized machining profilers, their general purpose machine tool lines should contain more standardization and modularity to compete for market share.

**Computer Integrated Manufacturing**

The introduction of VAX based cell controls, programmable logic controllers (PLCs) and area network communications technology extended automation beyond workstation applications. This led to the innovation known as CIM--computer integrated manufacturing. This technology allows linking workstations in an automated manufacturing cell.

The general trend is to make these manufacturing cells as flexible as possible. Manufacturing cells are flexible when: (1) a variety of products can be produced on the same machines or the same products can be produced on different machines; (2) new products can be produced on existing machines; and (3) the cell can accommodate changes in the design of products.

The key elements of a flexible manufacturing system (FMS) are the machining centers, industrial robots, or other computer controlled manufacturing equipment. A supervisory computer then controls these devices through a local area communications network. An automated material handling system (MHS) under the scheduling control of the master supervisory computer services each workstation. The heart of the MHS is the computer controlled automated guided vehicles (AGVs) that can be either wire guided or rail guided. The AGVs ferry parts and assemblies among individual workstations or to and from an automated storage/retrieval system (AS/RS).

Local and wide area network communications allow design and engineering information to be downloaded to computer controlled manufacturing equipment. Integrated CAD/CAM/CAE systems are growing by leaps and bounds. A lack of a single standard to provide compatibility between systems constrains this technology. This condition is an indication of intense competition and lack of a single source with a sizable portion of market share.

One measure of the degree of flexibility present in a manufacturing cell is the number of different parts made by the cell. This number varies around the globe. Compared to Japanese firms, American manufacturers have had less flexibility in their systems. In 1984, during the introduction of first generation FMSs, the average number of parts made by an FMS in the U.S. was 10 compared to the Japanese average of 93. For every part introduced into a U.S. FMS system, Japan introduced 22 parts.

In addition, equipment utilization for FMSs in the U.S. averaged 52 percent compared to 84 percent for the Japanese. Apparently, U.S. users are attempting to utilize FMSs for high-volume production of a few parts rather than for high-variety production of many parts. The prevalence of group technology design and production planning in Japanese industry could explain some of the difference. Group technology practices stress the design of part families and grouping similar operations better utilizes production assets. Matching product design and the flexible manufacturing cells group technology practices achieve the greatest reduction in unit cost.

We believe the American market will see the introduction of a second generation of flexible manufacturing systems during the 1990s. This generation will be more information intensive, more flexible and more affordable. This will be a stark contrast to the first generation systems introduced in the U.S. during the mid-1980s. We toured many of these original FMS installations. They resembled showroom demonstrators. Companies introduced the equipment at great expense without a strategy for exploiting the use of flexibility in the overall production process. This prior experience and the technical advancements in the equipment itself will yield more affordable second generation systems.

Our forecast is bright. The key technologies to be exploited will be in the areas of cell control and supervisory software. Eventually, "islands" of isolated automation will merge into "lights

out" factory cells able to operate around the clock. At FANUC in Japan, these "islands" are being integrated into a seamless automation of complete factories.

### Lean Production

At the plant level, most of the innovation is in the "soft" managerial and cultural aspects of the production organization. An MIT research team, led by Daniel Roos, reached a similar conclusion. They based their results on an investigation of automobile manufacturing practices. In a book titled The Machine That Changed The World[8], the MIT group identifies three types of production organizations--"craft" producers, "mass" producers and "lean" producers. Table II contrasts these production systems.

**Table II**
**Production System Comparisons**
(Source: Pine, Mass Customization, 1992)

| | Craft (1900s) | Mass (1950s) | Lean (1990s) |
|---|---|---|---|
| **Focus** | Single Basic Design | Standardization | Customization |
| **Goal** | High Performance | Affordable Prices | Affordable Variety |
| **Workers** | Skilled | Unskilled | Multi-Skilled |
| **Quality** | High/Inconsistent | Moderate/Inconsistent | High/Consistent |
| **Cost** | High | Moderate | Low |
| **Inventory** | Moderate Stocks | Large Buffers | JIT Deliveries |
| **Market** | Fixed | Stable | Fragmented |
| **Life-Cycle** | Long | Moderate | Short |

Craft production was the dominant form of organization in 1900. The use of highly skilled craftsmen to hand make variants of a basic design for each customer characterizes this system. In addition to producing small numbers of expensive end items, these decentralized organizations lacked the size to develop new technologies.

Mass production became the dominant form of manufacturing organization early in the twentieth century. Mass production typically employed skilled designers and unskilled workers who ran inflexible equipment to manufacture standardized parts. However, manufacturers needed large inventories to "buffer" the rigid processes in the system. The organization became more vertically integrated as the division of labor increased. Consequently, controlling the enterprise required large numbers of indirect specialists.

Lean production is now the "world class" organizational concept. It consists of multi-skilled workers using automated flexible tooling to produce large amounts of products in many varieties. Information is shared across the organization. This allows the identification of defect causes in near-real time. It also permits the transfer of a significant amount of responsibility to individuals adding direct value to the product. Supplier relationships develop based on long term contracts and information sharing to reduce costs. The organization is "lean" because the inherent flexibility of the system drives the "buffers" out of all levels within the enterprise.

We believe that the lean production cultural change will spread across all industries in the United States in the 1990s. By the year 2000, the U.S. will have a lean production economy. This transformation, begun with the Toyota Production System in the 1950s, is complete today in Japan. Europe is still in a mass production mode. The transition to a lean production economy indicates a

change in the way businesses accomplish manufacturing logistics and cost accounting.

### Manufacturing Logistics

Manufacturing logistics has progressed dramatically over the past three decades. Encompassing all of the activities necessary to optimize the actual production effort, manufacturing logistics, while often critical does not add direct value to the final product. Consequently, many believe they must minimize these activities as a cost and efficiency burden.

The introduction of Material Requirements Planning (MRP) in the early 1960's provided a means to tie material inventory management more closely to the manufacturing function. The main elements of MRP were the Master Production Schedule (MPS) and the Bill of Material (BOM). By establishing detailed production schedules and identifying material requirements for each step in the manufacturing process, manufacturers reduced the amount of inventory maintained on-hand and its associated costs. Further, MRP provided greater visibility and control over the manufacturing process itself, identifying and eliminating, through the MPS, inefficiencies at the shop floor level thus improving productivity and plant capacity planning.

In the late 1970s, Manufacturing Resources Planning (MRP II) provided a process to integrate all resource planning and production control processes in a manufacturing environment. MRP II includes all of the major manufacturing support functions of a firm including production, marketing and sales, financial management, design and industrial engineering, as well as inventory and materials management. As a closed-loop system, MRP II combines strategic planning with the operational methodology to achieve clearly defined company objectives. MRP II ties business and production planning to the shop floor through an interlocking set of master production and material delivery schedules to achieve order and coordination throughout the production process.

Just-In-Time (JIT) production, developed at the Toyota Motor Company in Japan, approaches the production process with the dual aims of eliminating waste and continuous improvement. Although JIT addressed the same logistics management issues as MRP, JIT users go beyond the concept of control and seek to eliminate all unnecessary logistics costs. Users accomplish these aims by eliminating inventory, group technology and manufacturing cells, sequential flows, uniform plant loading and stabilized schedules. Flexibility addresses variability, requiring the use of multi-skilled workers and highly responsive machine tooling. The key, therefore, to a successful co-operation is an empowered workforce, capable of responding to constant change and improvement.

The MRP processes help improve the efficiencies and cost effectiveness of traditional manufacturing firms. However, JIT provides manufacturing flexibility and demands workforce involvement in both problem solving and process improvement. It emphasizes continuous improvement of the manufacturing process at the shop-floor level by the workers themselves.

### Cost Accounting

Some background may be necessary to understand how traditional accounting systems build to product cost. To fully allocate costs, these systems divide cost into "pools" (overhead accounts) and then allocate these pools to the factor (labor, square feet, machine hours, etc.) believed to be most responsible for the costs. The cost pool for manufacturing overhead might include: supervisors, facilities, equipment, consumables, workers' benefits, utilities, and the indirect workers supporting the shop floor. If overhead costs are $3,000 and direct labor costs are $1000 then a factor of three must be applied to each dollar of direct labor cost to recover the overhead cost. Traditional accounting systems also apply this factor to determine the savings realized by

reducing direct labor costs. Therefore, saving one dollar of direct labor cost generates an "implied" savings of three dollars of overhead. Adding other factors to cover general and administrative expenses and profit determines the bottom line or price to the customer. Strict cost accounting standards govern what costs are appropriate for each pool and auditors constantly review and negotiate factors.

Jim Rigby[4], Division Controller of Hewlett Packard, points out that the shortcomings of this traditional approach include:

(1) misidentification of cause and effect relationships
(2) improper design initiatives
(3) pricing and profitability errors
(4) improper make-v-buy decisions
(5) irrelevant and untimely variance analysis
(6) misallocation of capital and resources
(7) nonproductive activities

The practice of factoring costs from a baseline of direct "touch" labor becomes even less appropriate as the growing level of automation decreases the percentage of touch labor. As industry continues to modernize and automate, the shift away from direct to indirect will accelerate. The ultimate result of this trend is the possibility of a highly automated factory in which thousands of indirect worker-hours are allocated to a base consisting of a relative handful of direct laborers. Under existing cost allocation methods, such a condition would place unacceptable pressure on overhead rates without regard to total costs.

According to Mark E. Belschef[5], a distinguished accountant and author, "Activity Based Costing (ABC) recognizes that costs originate from and are driven up or down by factors other than volume and direct labor." The ABC system assigns costs to the product based on the consumption of an activity by that product. An item that moves numerous times absorbs the costs associated with that movement. Products that remain in storage for long periods of time will experience high storage costs. The overall objective of the ABC system is to provide better information on the true cost drivers of a product and correspondingly how to reduce them.

While this appears reasonable each of these examples requires gathering additional data. Managers must understand the cost of activities and precisely how products consume these activities. There will continue to be activities that benefit the entire business base and businesses must allocate these costs. More commonly, however, there will be activities that have some traceable product benefit and some general benefit. Management decisions will be required to sort out the details, but there are some tools to assist. Process Value Analysis (PVA) is a systematic approach to help managers understand the manufacturing process.

PVA flowcharts each process step and the average time the product stays at each step. Next a determination is made as to whether the step is value added or not based upon whether the customer requires the step (e.g., the customer doesn't ask you to store material so storage is typically non-value added). Next management assigns costs to the manufacturing steps. The final PVA step proposes alternative actions. Done correctly, the process provides management with an accurate view of product costs and where to focus attention.

After years of wrestling with the problems inherent with traditional costs accounting systems, a growing percentage of U.S. companies think they have solved the problem. Converts

to ABC include General Dynamics Fort Worth Division, General Motors, Hewlett-Packard, Roseville Network Division, Martin Marietta Energy Systems, Inc. and Siemens. Their rationale includes a desire to better understand and control product costs, to better manage cash and liquidity, and to better support management decision making.

These companies realize understanding a process must precede improving it and even the best automated machinery cannot improve factory performance if it is not needed. Likewise "beating up" on direct labor will have little effect on costs when other parts of the factory indirectly generate the majority of those costs. The emphasis must be on the processes or activities affecting the product cost. Activity Based Costing illuminates these areas. Information systems and accounting systems can now support decision makers with pertinent information. Finally, we will have more than intuition to make an investment decision.

**Agile Manufacturing**

Beyond the plant level, corporations are beginning to link their resources and capabilities in strategic alliances. At first, corporations sought partnerships as way to penetrate protectionist markets. However, a new set of market dynamics now appears to be motivating this behavior. The new market force, discussed previously, is the demand for high value products. This includes the need for differentiated products to satisfy heterogeneous market niches. Time-based competition is more evident. This means that manufacturers must not only develop new products more often, but more quickly as well. Response to these pressures demands a flexible research and development capability.

The primary source of competitive advantage in this type of environment will be corporate agility--the ability to react to opportunities quickly. Maintaining tremendous depth in certain core competencies is the best way to remain agile. When a market opportunity exceeds the capabilities of the organization, then the corporation must be capable of entering into a strategic partnership with organizations that have the right competencies. This is the genesis of a "virtual" corportation. By combining the strengths of different manufacturing organizations, the virtual enterprise adapts and responds to the opportunities of an increasingly fragmented market structure.

This "agile manufacturing" concept is still not yet reality. Several obstacles must first be overcome. We must improve and standardize the nation's "information highway" infrastructure to permit efficient electronic linkage of geographically separated manufacturing operations. Reforms to anti-trust and intellectual property statutes must permit the "marriage" and "dissolution" of virtual enterprises as legal entities. The most significant obstacle is cultural. Competitive-cooperative partnerships must replace zero-sum business practices.

**Custom Order Economy**

In the distant future, well into the 21st century, another level of integration is conceivable--the industrial web. This is a natural evolution of the virtual enterprise. However, instead of forming temporary partnerships, corporation will form semi-permanent partnerships in diverse technological fields--chemicals, optics, electronics, power systems, structures, finance and banking, etc. The present day Japanese industrial groups, or keiretsu, are forerunners of future industrial webs.

We envision that future industrial webs will compete on the basis of product value only. The value of a new product will be so great that wholesale and retail distribution systems will cease

to exist. Customers will place their orders electronically from their home or office computer and receive products directly. In this environment a custom order economy will effectively replace our traditional retail system. The industrial web with the greatest comparative advantage will be the one that best fits each individual order.

Manufacturers will cost effectively design, develop and deliver production lot quantities of one unit. Artificial intelligence (AI) systems will make this practice economical by limiting the incremental amount of R&D expended on a new product. AI will accomplish this by catalogueing all new R&D and ensuring storage and retrieval when needed as part of a future product development.

## DEFENSE ISSUES

The U.S. defense establishment has developed and fielded weaponry that is clearly second to none--both in technological supremacy and unit cost. The defense acquisition challenge in the 1990s will be to create the capability to produce first rate weapon systems at a more affordable cost. We believe automated manufacturing will play a key role in the DoD response to this challenge.

### Weapon System Affordability

The industry study group believes that a greater amount of integration between the defense and commercial portions of the industrial base will yield more affordable systems. In addition, we believe that some portions of the defense industrial base, primarily the system level or prime contractor tier, will not be supported by the commercial economy. To improve weapon system affordability, we must eliminate excess capacity in this defense unique portion of the industrial base. We offer the following recommendations to implement these two strategies from an automated manufacturing perspective.

#### Integrated Industrial Base

Policies should strive to achieve the maximum amount of civil-military integration in dual use technology, products and operations. From a manufacturing standpoint, certain process technologies will facilitate implementation of dual use manufacturing operations. The July 1992 DoD Science and Technology (S&T) program advocates many of these technologies.

We support the S&T technical objective roadmaps established for the 6.2 funded technology efforts directed at design automation and a 6.3 funded thrust area for affordability. The DoD S&T investment portfolio places heavy emphasis on the development of flexible computer-integrated manufacturing (FlexCIM) technologies and demonstration of the "virtual factory" concept. This concept is the embodiment of an "agile manufacturing" system in which electronical links join geographically separated suppliers in a "virtual enterprise" to produce a common defense end item.

The DoD S&T program also recommends synthetic factory environments. This investment could reduce costs by allowing designers and production engineers to eliminate producibility problems without first setting up a production line. Engineers will create a mature production

process in a synthetic environment allowing the first production article to cost the same as the last production article. Ultimately, learning curves as we know them are eliminated.

In addition, revisions to defense procurement regulations should allow use of commercial procurement practices. Finally, the DoD should decrease the focus on direct labor standards in favor of an activity based accounting system.

**Defense Unique Industrial Base**

The Department of Defense must take an active role in managing the restructure of the defense industrial base. This is critical to create stable economies of scale; to create a lean production culture; and to ensure that "world class" firms thrive in the defense sector. Ultimately, the Congress and the DoD, as the sole customer for many unique defense items, have the responsibility to conduct long range strategic planning and to create smooth production profiles for its suppliers.

The Government should encourage a business led rationalization of excess production capacity. At each tier of the industrial base, conversion, closure or sell off must occur if the firm does not command a number one or two competitive dominance in the sector. In turn, the acquiring corporations must strip off excess capacity and consolidate the business base. At this point, customers and suppliers must establish long term relationships to control costs and incentivize capital investments in a sole-source or a diminished competitive environment.

The DoD should sharply reduce investment in public infrastructure--research laboratories, logistics depots and government operated production facilities--to further concentrate and stabilize the business base. For example, aircraft engine depot facilities and overhaul functions might be sold to the two major engine manufacturers (Pratt & Whitney Aircraft and General Electric). We should also explore other opportunities for privatization--like space launch services.

**Technological Superiority**

The possession of superior weapons is a tenet of U.S. military strategy. We believe that the U.S. must control the means to manufacture all critical defense-unique components of weapons systems. We can not depend on the global commercial economy for these items. This means that the DoD should pursue both "push" and "pull" strategies to maintain the edge in key manufacturing process technologies.

Over the past 40 years, the Department of Defense has traditionally "pushed" development of manufacturing process technologies through the production and logistics community. The Manufacturing Technology (MANTECH) program provided funds for research on manufacturing processes and for installation of advanced manufacturing equipment. In addition, the DoD Industrial Modernization Incentives Program (IMIP) provided a reward for contractors to use their own funds to develop high-risk manufacturing technologies by sharing the cost savings realized on government production programs. We recommend that these programs be strengthened and continued under the Director for Defense Research and Engineering (DDR&E).

Although the Department of Defense consumes 6.7 percent of the total U.S. manufacturing output, the Department has been marginally effective in stimulating "world class" manufacturing strength. In the past, the DoD has been successful in leveraging its buying power to create

markets for key process technologies. During the 1950s, the Government stabilized the U.S. machine tool industry through a guaranteed purchase of 87,000 general purpose machine tools. During the same time, the Air Force and MIT pioneered the development and created a market for numerically controlled machine tools. Today, we should consider a similar demand "pull" strategy to revitalize the industrial robotics and general purpose machine tool industries in the United States.

### Industrial Base Reconstitution

We believe that the key to rapid reconstitution of the industrial base is the agile manufacturing concept. We should stress industrial flexibility, not excess capacity. The Defense Department can take certain steps to ensure that defense items can be reprocured in an agile manufacturing economy. Defense procurements should make maximum use of flexible, automated and dual use facilities. Minimizing the requirements for defense unique manufacturing processes will help increase the use of flexible facilities.

The next step required for rapid reconstitution is electronic storage of the design. This should include the tooling designs and manufacturing processes used to produce the item. In addition, the DoD should continue to support development of open electronic data transfer standards to permit efficient transfer of design information. Finally, we should conduct a "smart" shutdown of the production line(s) at the end of an acquisition program taking care not to discard specialized tooling and "reprocurement" information.

## GOVERNMENT RESPONSE

The automated manufacturing technology areas where the U.S. is strong are generally those where the private sector has aggressively invested in technology and where the U.S. policy environment has been supportive. In engineering and production technologies, of which automated manufacturing is a subset, the U.S. is strong relative to its international competitors in computer-aided engineering and systems engineering. This reflects the historically powerful U.S. computer industry that has been able to sustain its lead through DoD support during the past several decades. It is also due to leading-edge U.S. university and computer industry research.

Many of our U.S. companies have business and manufacturing shops in foreign competitor's countries. These multinational corporations should seek to develop strong home base support structures for their business, secure a strong domestic market and take advantage of and invest in new technologies. This makes U.S. companies more attractive as suppliers to foreign firms who may at the same time be customers and technology partners, or could become them. Cross-border technology alliances may become essential to access in the world's markets. Through new rules and government supported arrangements, corporations may be able to form alliances to promote global technological progress.

At the same time, we need to implement a realistic trade strategy. Actions can and have included dollar devaluation, justifying sensible industrial safeguard and industrial rejuvenation efforts similar in nature to those existing in our trading partner's countries, more effective reciprocity and demands and enforcement of more equal trading conditions. Specifically, we propose imposing reasonable tariffs (around 10%), increased use of anti-dumping, countervailing duty and

safeguard remedies for distressed industries, such as automated manufacturing. GATT provides a playing field for the U.S. to defend and promote its own industrial and trade interests consistent with the approach of its trading partners.

State Extension Centers (with Federal support) can provide automated manufacturing assistance to small and medium sized businesses. These centers can serve as a clearinghouse for state and local initiatives on productivity, technology and innovation. Eventually, these centers should function as one-stop assistance centers to provide services ranging from managerial to technical advice technology transfer assistance. These centers could call on federal assistance and research in the appropriate areas. They would aggressively secure the interest and resources of universities in regional economic development. Finally, Centers could establish industrial application libraries.

Tax, statutory and regulatory policies should be reviewed, updated and aligned to ensure that (1) contradictions are eliminated; (2) a central, focused department or agency reviews all proposed government regulation or policy for consistency and impact and ensures adequate input and feedback from industry; and (3) regulatory policies agree with an overall national technology and competitiveness focus developed jointly by industry and government.

## CONCLUSION

Researching this topic and the industries associated with Automated Manufacturing reveals both problems and promise. The loss of the dominant position once enjoyed by U.S. manufacturers is obvious and undisputable. Equally undisputable, but perhaps not so obvious is the emergence of a new world economy. Just as industry replaced agriculture in the 19th century, information appears ready to supplant industry in the 21st century. The information age promises to reward the best integrator of knowledge, men and machines. In the future the walls of the factory and the borders of the nation will not define the market or the means to support it.

The U.S. is poised to exploit this new era like no other nation. In the fields of communication, computers, information, data management and transfer we are without peer. The foreign competition that has stripped away our industrial strength has perhaps exposed our real comparative advantage. The next 25 years will determine whether we exploit or export this advantage. Nothing less than the security of our nation is at stake.

## ENDNOTES

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# Industry Studies

# # 2

# Electronics

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## PLACES VISITED

### Domestic

| | |
|---|---|
| Concurrent Computer | Oceanport, NJ |
| IBM, Federal Systems Division | Manassas, VA |
| National Security Agency | Fort Meade, MD |
| ST Research | Newington, VA |
| TRW | Arlington, VA |
| US Army Communications and Electronics Systems Command | Fort Monmouth, NJ |
| Virginia Semiconductor Inc. | Fredericksburg, VA |
| UNISYS Paramax | Reston, VA |
| Watkins-Johnson | Gaithersburg, MD |
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### International

| | |
|---|---|
| GoldStar | Kyunggi-Do, Korea |
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## INTRODUCTION

This paper is submitted in partial fulfillment of the requirements of the Industrial College of the Armed Forces, Electronics Industry Study Program. The objective of the Industry Study Program is to:

- Develop strategic perspectives on selected industries and their role in the national defense
- Permit comparative analyses of U.S. and international industries
- Develop specific policy options to enhance industrial preparedness.

This document analyzes and assesses the American electronics industry and provides policy recommendations to assist the electronics industry in satisfying the national security objectives of the United States. Information used in preparing this report was obtained from individual study, lectures, academic research, as well as through extensive field research that involved visits to numerous domestic and international electronics companies and organizations.

## ROLE OF INDUSTRIAL BASE

With the demise of the Soviet Union, the nature of the threat facing our nation changed overnight. In turn, our National Security Strategy was modified to reflect the new international environment in which we found ourselves. We will still pursue ***Strategic Deterrence***, and to some degree ***Forward Presence***, but we will significantly reduce the size of our standing armed forces. While maintaining sufficient military force to allow ***Crisis Response***, we will rely on ***Reconstitution*** to regenerate a larger, more capable military force, should the threat to our national security increase significantly.[1]

While past experience permits us to feel fairly comfortable with the other legs of our strategic table, the concept of Reconstitution as a principal element of National Security is relatively new. Reconstitution applies not only to recreating global military end strength, but also to activating the defense industrial base to equip and re-supply our forces. Reconstitution assumes our ability to Mobilize...something this nation has not attempted in well over two generations.

The new importance of the long standing debate over the status of the industrial base is derived from the critical national security role of the defense industrial base. Reconstitution could prove to be a weakness in the strategy, as it depends to a large extent on a defense industrial base that may not be sufficiently forthcoming when the need arises.

The industrial base must satisfy two main objectives:

1) During peacetime...provide high performance weapon systems, at an affordable cost; and

2) During times of conflict...provide responsive production of weapons and support

equipment to satisfy the needs of our combat forces.

The Office of Technology Assessment (OTA) has developed a set of desired characteristics that the industrial base should posses to satisfy these objectives. From a national security stand point, the defense industrial base should exhibit the following characteristics:

- Advanced research and development capability
- Ready access to civilian technology
- Continuous design and prototyping capability
- Limited efficient peacetime engineering and production capabilities in key defense sectors
- Responsive production of ammunition and spares
- Healthy, mobilizable civilian production capability
- Good integrated management[2]

With these in mind, we analyzed the electronics industry, developing recommendations that would assist in directing the posture of the industry to be more in line with the characteristics needed for national security.

## INDUSTRY STRUCTURE

### Size and Scope of the Electronics Industry

The electronics industry has been a strong and growing part of the U.S. economy since consumers bought the first radio sets in 1920. Even during the recent recession, the value of the electronics industry increased by 1.5% in 1991 to $271.4 billion, while the overall Gross Domestic Product for the United States declined $36.1 billion.[3] The following table depicts U.S. production in the various industry groups within the electronics industry and how they have performed in terms of U.S. factory sales:

| Industry | ($Millions Per Year) | | | |
|---|---|---|---|---|
| Group | 1982 | 1986 | 1990 | 1991 |
| Electronic Components | 29,561 | 38,829 | 55,094 | 55,974 |
| Consumer Electronics | 6,369 | 6,571 | 8,115 | 9,057 |
| Telecommunications Equipment | 20,150 | 29,085 | 33,109 | 35,161 |
| Other Communications | 19,012 | 31,396 | 34,134 | 32,226 |
| Computers and Peripherals | 34,764 | 48,215 | 53,268 | 52,382 |
| Industrial Electronics | 16,473 | 20,286 | 24,960 | 23,336 |
| Electromedical Equipment | 4,402 | 4,931 | 7,010 | 7,535 |
| Other Related Products | NA | 39,117 | 51,571 | 54,684 |
| Total | 130,731 | 218,375 | 267,261 | 271,378 |

This table reflects the different segments of electronics and their contributions, showing substantial growth in most areas, but also portraying the effect of the recent recession on particular segments.

Private consumers and the government are the two big customers in the electronics industry. Consumer electronics total sales in 1992 reached $38.2 billion--a 7.9% growth over 1991, with imports dominating the field. Sales are projected to grow 3.5% in 1993.[4]

***Trends***

Using the companies visited by the Electronics Studies Seminar as a template for the electronics industry as a whole, various patterns and trends for the future are prevalent. The major trends encountered include:

- Downsizing
- Systems Integration
- Strategic Alliances
- Offshore Sales
- Quality Programs

These trends are discussed in greater detail below.

Downsizing. Virtually all the companies visited are going through some sort of downsizing. One obvious reason for this is shrinkage of the customer base, due to recession. Another major contributing factor to a decline in the size of the electronics industry is cutbacks in defense materiel acquisition. This has changed the business strategy of some companies. For example, one large company we visited had a 29%/71% split of commercial *vs* defense related business in 1991. Their goal is to achieve a 50%/50% split in three years. Another company's defense related business is steadily decreasing from a 50%/50% split it had in the early 1980's. Two other companies, while experiencing recent reductions in defense contracts are anticipating growth from defense related work in the near future. One of these companies is basing this optimistic projection on its ability to integrate systems to meet various demands; the other believes it is a strong competitor in the development of command, control, communication and intelligence systems, and expects to capture a larger share of a shrinking market.

Systems Integration. Many of the major companies visited are structuring themselves to develop products that rely on integrating commercial off-the-shelf hardware through the use of new software systems. These companies are integrating such sub-systems to meet specific customer needs in both the commercial and defense sectors. Each company has developed a unique descriptive phrase to characterize these actions--such as:

- Applied technology *vs* marketing technology
- Developing a niche in defense information sales
- Marketing systems integration expertise
- Developing multiple-application technology.

This business practice is really a subtle way for companies to stay competitive while

investing less and less in research and development.

*Strategic Alliances*. The high cost of doing business coupled with shrinking markets is causing another trend in the electronics industry. A business practice that has recently grown in popularity is forming strategic alliances. In the systems integration approach to developing products (as explained above), companies are forming partnerships with competitors. The high cost and risk of research and development are also driving companies into these alliances. Companies combine proven products and technologies to meet a customer's need.

*Offshore Sales*. Most companies visited do not seem to be changing their current strategies for competing offshore. There is a varying degree of participation in this market... from very little at some companies, to over 60% of one firm's profit attributed to overseas sales. Only one major company, however, expressed a strategy of increasing offshore business...its goal was to grow from 17% to 30% by 1995.

*Quality Programs*. Each American company took time during our visit to explain their quality program. There were varying degrees of implementation of a Total Quality Management (TQM) philosophy. If the programs are effective, adopting TQM principles will be a positive step in improving the competitiveness of the entire industry. Interestingly, however, in Japan we continued to hear that U.S. products are considered inferior to their Japanese counterparts.

## CONDUCT OF OPERATIONS

Through the course of study, several techniques repeatedly surfaced as principal methods companies use to conduct day-to-day operations. While it is expected that many of these factors are also prevalent in other industry sectors, business practices within the electronics industry are characterized within the following areas:

- Price Setting
- Government Acquisition Policies/ Actions
- Antitrust
- Management Practices
- Workforce Issues
- R&D Capital Expenditures
- Business Conduct/Decisions

These areas are discussed below.

### Price Setting

The large number of firms in the electronics industry makes it very competitive...however the concentration ratio (top five companies) for the industry is fairly high...52%. In the defense sector, the concentration ratio is only 27%. Another factor in setting prices is the intense competition from offshore companies. Our visits to domestic firms re-enforced that competition is the driving force in setting prices. The following are representative remarks from three such visits:

- "Our competitors are very good."
- "We are driven to a design-to-cost philosophy."
- "We strive to be among the lowest bidders."

**Government Acquisition Policies/Actions**

Issues in the electronics industry which are related to government policy and government/industry interaction fall into many categories. Principal areas include:

- Reduced DoD Budget
- DoD Acquisition System
- Control of International Sales

*Reduced DoD Budget*. The defense electronics industry has already felt the uncertainty of the future direction of the Defense Department's downsizing efforts. However, uncertainty of the future direction of the DoD's electronics and weapons system needs as well as their focus is also present. As a result, companies are maintaining some level of anticipatory capability which is not particularly profitable and cannot be maintained for long. In addition, the instability of DoD funding for both current and future projects was identified as a major problem by many of the defense electronics firms.

*DoD Acquisition System*. In addition to the issue of funding instability, all companies identified the DoD acquisition system as a problem area. Areas most frequently cited as needing improvement include:

*Oversight*. The amount of oversight invoked on DoD contracts has continued to grow over the past several years. A great deal of money continues to be spent by defense electronics firms to meet regulatory requirements in the oversight areas...causing the prices for DoD electronics to continue to rise.

*Contract Terms*. Terms and conditions of many DoD contracts make it difficult to use commercial parts and commercial products in defense systems, even when it is clearly cheaper as well as technologically feasible to do so. The DoD must make significant strides in this area in the near future if industry is to fully realize the efficiencies that can be obtained through the use of dual-use and flexible manufacturing technology.

*Accounting Procedures*. The cost accounting criteria on many government contracts as well as the generally higher costs of doing business with DoD will continue to cause some small electronics companies to question doing business with DoD in the future. The bid and proposal costs and the costs of auditing proposals have continued to increase. There is often no value added to repeated iterations of proposal submissions on defense contracts. The result is not only an increase to the price of DoD electronics systems, but a reduction in a company's competitive posture in the commercial electronics market.

*Control of International Sales*. All firms visited by the group, both large and small, identified the need for the government to take a more active role in the area of international sales in order to maintain and expand sales volume. Many U.S. defense and commercial electronics firms have already begun to more actively pursue foreign sales. It

will be important for the DoD in the future to work with industry, both to reduce the costs of items as well as to minimize the restrictions on selling internationally. This is absolutely necessary if our electronics firms (especially defense electronics firms) are to be competitive with their foreign counterparts.

In addition, several of the large electronics firms believe that they would have significantly greater sales overseas if not for the restrictions invoked by the Coordinating Committee for Multilateral Export Controls (COCOM). With the dissolution of the Warsaw Pact and the opening of markets in formerly forbidden areas, the necessity for some of the current restrictions need to be reevaluated. Also in this area, U.S. sales overseas have been hurt because the participating COCOM countries do not operate under the same ground rules. Specifically identified were Germany and France, each of whom is now producing competitive electronics systems, but with far fewer restrictions on international sales. This can become particularly important since the initial sales of electronics items and systems often leads to future sales, especially in the areas of maintenance support, product improvements, compatible upgrades, and systems integration.

**Antitrust**

The government needs to reevaluate its antitrust position. With the ever increasing benefits of alliances between electronics firms (both domestically and internationally) almost all large electronics firms are actively pursuing alliances. In some cases, it appears to be easier for U.S. companies to form international joint ventures than domestic ones. Congress partially recognized this with the passage of the National Cooperative Research Act in 1984, which allows collaborative R&D among U.S. firms, but it remains difficult for U.S. companies to form joint production ventures. With competition becoming increasingly global, we cannot afford to place stricter antitrust burdens on U.S. firms than we do on foreign companies operating in America.

**Management Practices**

There are several factors affecting management philosophy. Based on our observations, the electronics industry has embraced the total quality management (TQM) philosophy. TQM bulletin boards and posters were readily visible at every company we visited. Many companies were very proud of their TQM efforts and briefed us on them during our visits.

A second factor affecting management practices is the move from vertical integration to horizontal integration. Most large companies are eliminating layers of management in an effort to reduce overhead costs and reduce their time in getting new ideas to market.

**Workforce Issues**

Because of the downsizing of the defense industrial base and the overall weakness of the economy during 1992-1993, the mobility of the workforce has been severely reduced. In the past year, employee induced turnover within the electronics industry has therefore been minimal. One of the smaller firms visited actually had no employee turnover during the past calendar year.

There is no general lack of skilled labor in the electronics field. In fact, several of the firms believed that they had the luxury of hiring only engineers from the top colleges in the nation. Many companies, however, noted that shortages did exist in the fields of software engineering and computer science. At least two of the firms recruit junior and senior college students in those disciplines via summer jobs and limited internships in an effort to keep the pipeline of critical skilled employees filled.

There is at least one cloud on the workforce horizon. As the military drastically reduces its forces, there will be a temporary glut of skilled technicians in the electronics field. After the downsizing is complete (during the next three to five years), the number of military trained electronics workers will dwindle significantly. In the future, industry will have to rely on in-house training programs, vocational education, or commercially operated electronics schools to provide technician training. In any case, shortages in trained technicians could prevail for an appreciable length of time.

None of the companies visited indicated a significant problem with the family leave legislation signed earlier this year by President Clinton. The law authorizes up to 12 weeks of unpaid leave for illness in the family. One small business, however, expressed concern over workman's compensation laws, relating the difficulty in preventing worker abuse of the benefits provided under the current system.

Most of the companies visited indicated that they would continue to reduce the workforce in the future. Several companies had gone through rather severe reductions in personnel, with some of the larger firms having eliminated several thousand workers. One firm actually eliminated an entire layer of middle/upper management in an effort to remain competitive. Two of the manufacturing firms indicated that they believed that automation and robotics would allow them to reduce their workforce even further.

Several American companies indicated they were increasing their overseas sales forces, in an attempt to expand their markets. They noted, however, that the cost of overseas sales was double the cost of domestic sales. One firm stated that they were not looking at overseas markets precisely because of the increased personnel and travel costs associated with European and Asian markets. One firm highlighted the extra personnel and travel costs of doing business in Japan as a distinct detractor.

Many companies indicated that they were organizing and re-structuring around their "core competencies," and their workforce size and attributes would reflect this effort.

**R&D/Capital Expenditures**

Electronics is a high technology industry that relies on research and development (R&D) to survive. In 1989, the electronics industry (SIC 36) spent $16.8 billion (commercial and federal) on R&D. This is a 3.2% increase over 1988 and represents about 10% of the total national expenditures for R&D. Due to the technological complexity, foreign competition, and short product life cycles, the electronics industry has traditionally outperformed other industrial sectors in the percentage of revenue spent on R&D. However, in recent years, the rate of growth in R&D spending has decreased from an average of 17% per year in the early 1980's to 7% in the last half of the 1980's[5].

Our visits to industry confirmed this trend. In Korea, however, there was open recognition of companies past position as technology followers. In efforts to compensate for their technological lag, many companies were planning to increase R&D expenditure to around 10% of revenue. Additionally, several American firms have reoriented their R&D from a technology innovation focus to a product and production engineering focus.

As the defense budget continues to decline, we found that a majority of firms are redirecting their capital expenditures from defense related activities to commercial activities.

### Business Conduct/Decisions

Our visits to large American electronics firms indicated they are in the midst of a corporate cultural change in the basic way they do business. Firms are stressing "core competencies" and are emphasizing teaming with other companies to obtain the required expertise to pursue new markets when necessary. The bottom line decision on pursuing new business seems to be cost. Can a firm be one of the lowest bidders? If not, it doesn't even attempt to compete. Large Japanese firms have generally not embraced this focusing trend, and are remaining with large vertically integrated corporate structures. When questioned on the divergence of this aspect of organizational structuring compared to the American trend, one Japanese executive stated that he believed American firms were two to three years ahead of Japanese companies in efforts to restructure more efficiently.

## OUTLOOK

### Commercial Forecast

The overall electronics industry outlook is very positive. It is expecting growth this year of seven to ten percent over last year. Updated models are coming out for existing products and some new product lines will be coming out creating whole new markets.

### Defense Forecast

Even though the DoD budget is getting smaller, the funds programmed for defense electronics R&D and procurement are remaining constant. In the grim world of DoD acquisition, the electronics sector is therefore a bright spot. While defense only accounts for fourteen percent of electronics sales, industry growth will have to come within the commercial sector.

### Potential Markets

The world is becoming more dependent on electronics for everything from efficiently maximizing industrial control systems to communications and information management systems, to purely consumer related entertainment systems. With new products coming out and new applications for existing products the market is expanding rapidly in government, industrial and consumer areas. The military market will depend on upgrades and modification, with a limited number of new products for the foreseeable future.

## STRATEGIES FOR SURVIVAL

Declining demands from the defense sector have compelled most electronics firms to downsize ("rightsize") their companies in search of the best formula for present and future markets.

Several strategies are being pursued. These include:

- Downsizing through sell-offs to share returns with investors
- Acquisition of other companies to prepare for future demand
- Convert existing production lines to flexible production
- Transition to non-defense markets
- Increase export of defense business

*Downsizing*. This is an attempt to shed excess capacity while maintaining a competitive base for future markets. Over 1 million people overall may be laid off due to this effort by 1997 in defense related industries. Electronics may be better off in this area than other sectors since the defense budget for electronics remains relatively constant for the near term.

Downsizing is also being pursued through sell-offs of excess capacity. Such tactics increase stock value and returns to investors, but do not necessarily produce a stronger company. Resources must also be consolidated to shrink overhead and build a more competitive company.

*Acquisitions*. These are strategies for the more optimistically minded. These companies believe defense spending will rise in its usual cyclical fashion, and they will be ready to compete in that market. Teaming with other contractors is part of this strategy. Shared costs and expertise make this an attractive option in times of tight budgets. Smaller companies are forming networks to achieve the same results sought by larger companies. Many companies see this as a competitive advantage for future requirements where excessive overhead will be a detriment.

*Flexible production lines*. This technique offers the opportunity to produce multiple products at a single facility. DoD is a proponent of such lines and sees them as a cost saving measure. "Soft tool," flexible machines and agile teams are used to complete short production runs without the inherent high costs. Customized chip production is one of the strategies being pursued most vigorously through flexible production.

Flexible manufacturing and production could have a significant impact on small electronics firms which catered to niche markets. If larger companies are able to adapt to smaller runs of custom items, they will undoubtedly compete directly with many of the smaller firms.

*Conversion*. The transition from defense related work to non-defense is probably the most difficult of the strategies to pursue. Most defense firms acknowledge a lack of expertise in the marketing and production of ommercial products. That lack of expertise is a training problem which will take time to overcome. Examples of success in this strategy are very hard to find. Several companies are attempting to move from a high percentage of defense production to an even split between commercial and defense by the end of the decade. Only time will tell whether this is a wise strategy.

*Defense Exports*. Increasing exports of defense products is one way to help the defense electronics industry. However, political and social concerns throughout the world will probably keep these firms from expanding to anywhere near what they believe they need to make up for the drop in U.S. procurement. Markets are available for these items, but their sale may greatly complicate our own military problems as other nations become comparably equipped but have less stable governments.

**Impact**

The impact of these strategies is difficult to predict except in the very near term. Each firm has its own vision of the future and is planning company size and capability to meet the requirements of that vision. Large companies could become obsolete through teaming efforts, or small firms could be hurt badly by successful implementation of flexible production. Electronics firms will survive and thrive due to the nature of their products and the market for such capabilities. It is too early to predict which strategy will afford the best defense electronics capabilities for the future.

## PRESCRIPTION FOR THE FUTURE

Industrial organizations respond to market forces in shaping the business strategies. While the total DoD electronics budget only encompasses about 14% of the total electronics industry sales, government policies and practices still represent a strong force in establishing future corporate direction. The following policy initiatives warrant implementing to help guide the electronics industry in a direction that will satisfy both consumer demands and the national security objectives of our country.

- Increase research and development (R&D) efforts. Several steps can be taken to enhance the level of R&D, as well as to focus efforts on critical capabilities.

- Expenditures on R&D should be encouraged by making the tax credit allowed for R&D expenditures a permanent part of the U.S. Tax Code. IRS rules should also be modified to encourage applied research, commercialization of technology, as well as manufacturing process and product development.

- Provide R&D funding to develop dual-use technology and technology applicable to implementation of flexible manufacturing processes.

- Fully fund R&D efforts, encouraging solid design decisions during the early phases when the majority of decisions that affect life cycle cost are made.

- Emphasize Long-term investment. Adjust tax codes to tax short-term capital gains at a higher rate than for gains made over a long period of time.

- Encourage capital investment. In order to encourage increased expenditures on capital equipment and facilities, two proposals are forwarded:

  - Reduce the depreciation schedule for production equipment subject to high rate of technology turnover, permitting investments to be amortized over

a period of time that more closely coincides with the product life.

- Modify payment on government cost reimbursable contracts in the following manner...Reduce profit paid by 1%, and increase allowable reimbursement for capital investment by 2%. In this way contractors making such investments will experience no loss in payments.

• Streamline federal procurement. The federal acquisition system needs major modification if desired efficiencies are to be obtained. While the "Section 800 Panel" has presented hundreds of such recommendations, several such recommendations are provided below:

- Explore methods that permit sharing of rights and data between the government and the developing contractor.

- Develop federal accounting standards that encourage coordination of commercial and government development efforts within shared facilities

- Raise the dollar value of Small Procurements from the current limit of $25K to $100K.

- Permit the use of standard commercial procurement practices when commercially available items are being purchased.

• Streamline export control procedures. Virtually all American companies visited desired a more effective government role in international trade to "help level the playing field." Some helpful actions include:

- Reducing the time to obtain export approvals.

- Bringing the criteria for export of military equipment in line with the criteria of other nations supplying similar equipment.

## SUMMARY AND CONCLUSION

Overall, the U.S. electronics industry is healthy. According to some sources, it is 'poised for recovery.' Despite the down-turn in defense expenditures, funding currently programmed for R&D and procurement of electronics systems remains constant through the end of the decade. Companies have recognized the challenges associated with competition in the global marketplace and are taking appropriate steps to restructure, "rightsize," and implement management initiatives to enhance and solidify their competitive postures.

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3. Laurie Adler, ed., 1992 Electronic Market Data Book (Washington, D.C.: Electronics Industries Association, 1992), p. 1.

4. Electronics Industries Association, Consumer Electronics U.S. Sales 1989-1993 (Washington DC: Electronic Industries Association), p 10.

5. Electronic Industries Association, 1992 Electronic Market Data Book, Washington DC, 1992, p.120-2.

# INDUSTRY STUDIES

## #3

# NUCLEAR

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### Domestic

| | |
|---|---|
| Department of Energy | Germantown, MD |
| Assistant Secretary of Defense (Atomic Energy) | Pentagon |
| The Joint Staff (J-5) | Pentagon |
| Department of Energy | Washington, DC |
| Nuclear Regulatory Commission | Rockville, MD |
| United States Senate | Washington, DC |
| Defense Nuclear Agency | Alexandria, VA |
| Defense Intelligence Agency | Bolling AFB, DC |
| Oak Ridge Nuclear Reservation | Oak Ridge, TN |
| Three Mile Island Nuclear Plant | Middletown, PA |
| Kansas City Plant | Kansas City, MO |
| Los Alamos National Laboratory | Los Alamos, NM |
| Waste Isolation Pilot Plant | Carlsbad, NM |
| Sandia National Laboratory | Albuquerque, NM |
| Nevada Test Site | Las Vegas, NV |
| US Strategic Command | Omaha, NE |

### International

| | |
|---|---|
| UK Ministry of Defence | London, England |
| British Nuclear Fuels, plc | London, England |
| Atomic Weapons Establishment | Aldermaston, England |
| British Nuclear Fuels, plc | Springfield, England |
| British Nuclear Fuels, plc | Sellafield, England |
| Normandy Staff Ride | Normandy, France |
| COGEMA | La Hague, France |
| Commissariat a l'Energie Atomique | Paris, France |

## OVERVIEW

The Nuclear Industry Study addressed the singular challenges of two distinct industries--the nuclear weapons complex and the nuclear power industry--which share oversight and management by the Department of Energy and which benefit from the research efforts of DoE's national laboratories. Although the problems of each are unique and require decisions on future directions from different sets of policymakers in DoE and elsewhere in the federal, state and local government structures, they also share a major common concern: how to deal with the environmental legacy of nuclear materials production and use.

The nuclear weapons complex, managed by the Department of Energy (DoE) and the Department of Defense (DoD), faces ongoing cutbacks in manpower, facilities, and funds. The National Laboratories, a unique scientific and technological asset, are seeking new missions and new partners to stay in business. Arms control agreements and proposals for unilateral reductions by President Bush have called for continuing reductions in nuclear weapons. Congress has enacted a moratorium on nuclear testing, which will expire on July 1, 1993, allow 15 underground tests over the subsequent three years, and then bring a permanent halt to testing; organizations within the nuclear weapons complex are concerned about the safety and reliability of the aging stockpile in the absence of future tests after 1996. Reconstitution of our capability to design and manufacture nuclear warheads should the need arise is a critical issue for the industry.

Nuclear energy satisfies over 20% of our need for electricity, yet no new plants have been started for more than 15 years. Environmental and community concerns continue to make nuclear power controversial, while the economics of fuel and plant construction have made natural gas and other fuel sources a more attractive alternative. As existing nuclear plants age, however, and come up for license extensions, decisions must be made on continuing use of nuclear energy as part of the United States' energy mix.

Even if all weapons were eliminated and all power plants shut down, the issue of nuclear waste would continue to haunt us. The production of nuclear weapons and their materials under strict security and with few environmental controls has resulted in a legacy of contamination and hazard at Department of Energy facilities in Hanford, Washington, Rocky Flats, Colorado and Savannah River, South Carolina. Cleanup costs have been estimated at more than $300 billion. Spent fuel from nuclear power plants is currently being stored at each plant, with no solution in sight for permanent disposal. The United States decided against reprocessing spent fuel from reactors during the Carter administration because of fears about the increased availability of plutonium to nuclear proliferators and terrorists. England and France both reprocess reactor fuel from their domestic power plants and for foreign customers, greatly reducing the amount of material that needs to be permanently stored.

Although the members of the Nuclear Industry Study do not unanimously support all recommendations contained in this report, we are agreed that the nuclear industry faces difficult decisions in the years ahead. The commitment of industry leaders and policymakers to our nation's well-being and security was demonstrated in our discussions throughout the semester; the pride of all industry representatives in what the nuclear weapons complex and the nuclear power industry have accomplished in the last 50 years was obvious. The question now is how to maintain the contributions of the industry to our national security and economic

welfare while adjusting to the changing world and addressing the waste management and cleanup issues. This report concludes with recommendations addressing this question for consideration by policymakers and industry leaders.

## NUCLEAR WEAPONS COMPLEX

### Introduction

Management of United States nuclear weapons production and use involves two executive departments: the Department of Energy and Department of Defense. In addition, the Defense Nuclear Agency's mission encompasses nuclear weapons operations from the stockpile to the target, while the US Strategic Command would be the user of weapons in the strategic inventory. Each year the President issues the Nuclear Weapons Stockpile Plan, as required by the Atomic Energy Act of 1954, to authorize the production and retirement of nuclear weapons, as well as the Nuclear Weapons Test Plan. Congress authorizes and appropriates funds and conducts oversight of the program.

The separation of responsibilities for nuclear weapons production and use between the two executive departments is a result of concerns since the beginning of the atomic age about civilian control of the design and development of the weapons. The Department of Energy (created in 1977) is the successor to the Atomic Energy Commission. The nuclear weapons complex consists of 13 sites administered by DoE in 12 states; DoE's Complex 21 plan to reconfigure the complex calls for closing down several of these sites and consolidating their functions.

### Complex 21: Weapons Complex Consolidation

DoE's 13 sites in the nuclear weapons complex produce nuclear materials; perform research, development and testing of nuclear devices; design and manufacture nuclear weapons; and provide surveillance and maintenance for and dismantling of nuclear weapons in the national stockpile. Nonnuclear manufacturing is performed at the Kansas City Plant (MO), Mound Plant (OH), Y-12 Plant (Oak Ridge, TN), and Pinellas Plant (FL). Nuclear materials production and manufacturing takes place at the Pantex Plant (TX), Y-12 Plant (Oak Ridge, TN), Idaho National Engineering Laboratory, Hanford Site (WA), Rocky Flats Plant (CO), and Savannah River Site (SC). Dismantling is done at Pantex. Research, development and testing sites are at three national laboratories (Lawrence Livermore, CA and Sandia and Los Alamos, NM) and the Nevada Test Site.

Currently, no new weapons design or production is underway. Stockpile improvements are planned, particularly to enhance the safety and reliability of warheads, but the weapons complex has considerable excess capacity and little prospect for increased workload in the near term. The labs and manufacturing plants are looking for additional business beyond nuclear weapons-related manufacturing and assembly/dismantling, and have undertaken campaigns to bring in contracts and provide expertise to commercial firms based on their facilities and personnel. In addition, several of the weapons complex facilities have been closed, at least temporarily, because of environmental hazards; cleanup at Hanford and Rocky Flats is critical.

As a result of these factors, DoE has proposed consolidation of facilities to develop a smaller, more centralized, less expensive nuclear weapons complex. The most comprehensive of several versions of its plan calls for closing Rocky Flats and Hanford and moving non-nuclear manufacturing operations from Mound and Pinellas to Kansas City.

We support the DoE proposal to consolidate facilities, to move all non-nuclear manufacturing operations to Kansas City, and to close down and clean up Hanford, Rocky Flats and Savannah River. The need for redundant facilities to provide protection against an attack on a single facility which could wipe out a capability has long passed. Sufficient capability exists in the laboratories to produce plutonium, should the need arise, and tritium recapture in the process of dismantling warheads will satisfy needs for stockpile maintenance at current levels into the next century. Maintaining the existing overcapacity on the nonnuclear manufacturing side makes no economic sense, and the prospects for needing this capacity to start up weapons manufacturing in the near term are negligible. The DoE complex must be reduced so that truly critical capabilities can be maintained.

**National Laboratories, National Asset**

Within the weapons complex, the national laboratories have played an essential role. Starting with the Manhattan Project, the labs have conducted basic science research and provided expertise, materials, and manufacturing technology for the design and production of nuclear warheads. The labs' nuclear weapons research currently accounts for $3.5 billion annually. With no new warheads in development, and the weapons work remaining centered around maintaining the stockpile and dismantling excess inventory, the weapons program money will dwindle, and the need to find new sources of funds will increase.

DoE and the labs have undertaken several initiatives to open their doors to commercial projects. More than 800 cooperative research and development agreements (CRADAs) have been established between the lab complex (including all labs, not just those in the nuclear weapons complex) and private businesses, in accordance with the 1986 Federal Technology Transfer Act. Technology transfer centers have been opened at the labs to work with local industry and make available basic technologies for development into commercial applications. To date, the results of these initiatives have not been spectacular, but progress appears to be steady and should increase as firms and the labs become more creative in identifying potential applicability of lab-developed technology.

The Nuclear Industry Study group supports the continued existence of the three nuclear weapons complex national laboratories (Sandia, Los Alamos and Lawrence Livermore), for the near term, as well as DoE's ongoing efforts to put the labs' work and facilities at the disposal of commercial interests. We do not support any kind of subsidy to the national lab complex over the long term in an effort to maintain a "laboratory base" (comparable to the "industrial base") for weapons-related reconstitution or mobilization: if the labs cannot perform enough non-weapons-related work, together with weapons-related improvements and environmental restoration, to be self-supporting, we believe a consolidation of functions and decrease in the number of labs in the future would be justifiable, to the extent that a single lab could support the weapons complex. As long as three is a US nuclear stockpile, there will be a need for a lab to support its maintenance.

## Nuclear Weapons Inventories

As a result of treaties between the United States and the Soviet Union and its successor states, and unilateral initiatives by President Bush, the inventory of US nuclear weapons is decreasing rapidly from Cold War levels. According to the February, 1993 Roles, Missions, and Functions of the Armed Forces of the United States, we are moving toward a total of about 5,100 weapons--one quarter of the Cold War inventory. Remaining strategic warheads will number no more than 3,500 on the U.S. side, and 3,000 on the Russian side by 2003, down from an estimated 9,800 for the U.S. and 10,900 for the Russians in January, 1993. No new nuclear weapons are currently being produced or designed by the United States. Although the treaties do not require warhead dismantling by either side, the US is dismantling warheads at Pantex, a DoE government-owned, contractor-operated (GOCO) facility in Texas. Pantex is able to dismantle about 2,000 warheads a year. Storage of the plutonium components will be done at the Pantex facility on an interim basis, although the community and state are pressing the DoE to conduct an environmental study and come up with a plan for permanent disposal.

Even as the total inventory of warheads is decreasing, work is underway to monitor and improve the safety, security and reliability of the stockpile that will remain. Major improvements include the use of insensitive high explosives (IHE), designed to further limit the possibility of accidental explosion of a warhead, and detonators that use fiber optics technology.

The Industry Study participants support the reduction in weapons in accordance with treaties and presidential initiatives, with appropriate verification and safeguards, and believe it is imperative that strong intelligence capabilities remain in place to detect at early stages any potential deviation, or intention to deviate, from agreements on the part of the former Soviet Union (FSU) states. We also support efforts by DoE to enhance the safety of warheads in the stockpile.

## Weapons Testing

U.S. underground testing has been suspended under a moratorium enacted by Congress in the FY93 Energy and Water Appropriations Bill (the "Hatfield amendment"). The moratorium will remain in effect until July 1, 1993, then allow a maximum of five tests per year, with a total of 15 tests in all, before banning testing after September 30, 1996. In the interim, the U.S. is to seek a comprehensive test ban treaty. Under the legislation, if another nuclear state were to resume testing, the United States would also be allowed to do so. Currently, all nuclear states have suspended testing unilaterally.

Throughout the organizations of the nuclear weapons complex, there was concern that prohibitions on testing, and the small numbers of tests allowed before the final ban, would adversely affect the stockpile's safety and reliability. Even in the absence of new warhead development and production, engineers and scientists felt that computer modelling and above ground experiments cannot provide the same kind and level of detail of information about nuclear explosions and nuclear weapons effects that real nuclear tests give them. They stressed that, even with fifty years of experimentation behind them, there are still many unknowns in nuclear weapons, particularly as warheads in the stockpile age far beyond their

designed and anticipated lifespans. There was also concern that the expertise of current employees would atrophy, and that many would leave the weapons complex with little motivation for young scientists to replace them.

The British also use the Nevada Test Site for their nuclear weapons tests, and expressed concern in our discussions at the limited window in which to complete their work (they may utilize up to three of the 15 remaining allowed tests at the rate of one per year) and at the impact on development of future nuclear weapons for their inventory.

The arguments against testing include the costs involved (millions of dollars per test), the absence of justification for development of new warhead types in view of the changed world situation, and the U.S. leadership we would demonstrate in non-proliferation efforts by stopping testing and working toward a permanent ban. The sense of Congress seems to be that our renunciation of weapons tests, together with that of other nuclear weapons states, will exert pressure on "wannabe" nuclear states to comply with a testing ban (although it would be possible to develop a warhead and explode it operationally without prior testing). The three-year window for limited testing is designed to allow the weapons complex to further develop and validate computational models and permitted experiments, prototype safety enhancements for the stockpile, and put together a team to manage the stockpile after 1996 in the absence of testing.

The Industry Study group was not able to reach consensus on the need for continued testing after 1996. Although testing may be viewed as unnecessary from 1993's perspective, it may turn out that advances in computational modelling or other experimental techniques cannot be achieved that would allow stockpile improvements in the absence of testing. Also, our special relationship with Britain may be affected if they are forced to find alternative testing opportunities, which could be available if there is no comprehensive test ban in place by 1996. Many individuals in the nuclear weapons community expressed their concern that the three-year window for testing is insufficient, but no one offered a reasonable and politically palatable alternative. We believe that a comprehensive test ban is a desirable goal but that the U.S. should retain its option to continue testing, strictly for safety improvements to the stockpile, until a ban is agreed to by all nuclear states through a treaty.

**Nuclear Proliferation**

The proliferation of nuclear weapons as one of the categories of weapons of mass destruction continues to be one of the most important issues in the world today. Even as the superpowers reduce their inventories, smaller states' desires to acquire nuclear weapons remain. The January, 1993 National Security Strategy notes, "As the threat of nuclear confrontation with the former Soviet Union recedes, the danger that a nuclear, chemical, or biological weapon will be launched from some other quarter by an aggressor is growing." As we learned in Iraq, even supervision of power reactors by the International Atomic Energy Agency (IAEA) and signing the Nuclear Non-Proliferation Treaty (NPT) does not prevent a determined state from pursuing a weapons program. South Africa announced this year that it had developed nuclear weapons, in spite of denying its efforts for years, and was now willing to destroy them. Inspection of North Korea's nuclear program to determine if they are working on a weapon is a continuing problem, with the country declaring a wish to renounce participation in the NPT. The Treaty itself will expire in 1995; negotiations over its renewal will

undoubtedly be extensive and acrimonious.

The broadening of IAEA's role to include nuclear weapons programs in addition to their traditional emphasis on power programs is to be applauded, but resources available to the agency do not yet appear to match their new efforts. Provision of US expertise (in personnel, equipment and information) to IAEA in support of their monitoring of weapons programs should be undertaken on as broad a scale as necessary.

We also applaud the reorientation of the Arms Control and Disarmament Agency (ACDA) to include nonproliferation support. We believe it would be justified to increase ACDA's funding and personnel to perform this mission.

Despite speculation in the media on "loose nukes," we have seen no evidence this year of breakdowns in Russian or other FSU states' control of nuclear weapons and materials. Russia faces an enormous environmental problem caused by weapons production, and also needs assistance on dismantling and storing weapons and components. The efforts of our national laboratories and federal agencies to assist Russia should be expanded to the greatest extent our finances and Russia will allow. U.S. money spent on eliminating Russian warheads now will pay us back many times in assurance that the job was done right and in weapons and defenses we will not have to build or maintain in the future. Support to their technology centers which employ scientists and engineers from their weapons complex will also pay dividends through keeping this talent in Russia or other FSU states rather than moving to assist "nuclear wannabes" in their proliferation effort.

## COMMERCIAL NUCLEAR POWER

### Introduction

Unlike the nuclear weapons complex, where the federal government is the single customer for the product, the U.S. commercial nuclear power industry is a key segment of a much larger electrical power production industry composed of over 250 electrical utilities ranging from large, government-owned systems like the Tennessee Valley Authority to small, rural cooperatives. Private utilities own more than three-quarters of the nuclear power infrastructure, valued in excess of $245 billion, with the remainder divided among a number of cooperatives, municipalities, and other private firms. As Chart 1 shows, nuclear power is the source for over 20 percent of the electricity generated in the United States, and the National Energy Strategy projects it to remain at that level through 2030. Today, 54 utilities operate 107 reactors at 71 power plants located nationwide (two reactors have been closed since the chart was published). Chart 2 illustrates the distribution of nuclear power plants within the United States.

Worldwide there are 420 plants in 26 countries which generate 22 percent of the electricity in countries with nuclear power plants, and 17 percent of the world's overall electricity. Chart 3 shows nuclear power generation in selected countries, with France being the leader in the nuclear industry.

### The Future of the US Nuclear Power Industry

Nuclear power has expanded dramatically over the past 2 decades. While overall electrical demand rose at a rate of less than three percent each year, nuclear power generation grew at an annual rate of 13 percent, making it a major source of U.S. electricity--second only to coal. The rosy view of nuclear power's past production growth, however, belies the current health of this key industry. While nuclear power enjoyed a period of rapid growth from 1965 to 1974, when the industry ordered over 220 new reactors, it has entered a period of major retrenchment. Since 1975, over 100 reactor orders have been canceled. No new reactors have been ordered since 1978 and none ordered since 1974 have been built. Now, there are only two nuclear plants under active construction, six partially built but in a deferred status, and one in planning.

The commercial nuclear power industry in the United States is slowing strangling from a combination of political, economic, and regulatory constraints; a lack of public support; and a short-term approach to operating and expanding the nuclear power industry. Like other domestic industries and elements of the US infrastructure, without an immediately recognizable crisis, nuclear power will continue to stagnate or decline.

Nuclear energy is strategically, economically, and environmentally irreplaceable in the United States. The mid-1970s energy crisis forced the United States to concentrate more on domestic energy resources. Electric power, which accounted for 25 percent of U.S. national energy use in 1970, will account for nearly 50 percent by 2000. Many experts consider oil supplies to be too valuable and unreliable for long-term use in power plants. This leaves coal, natural gas and uranium as domestic fuel sources for meeting a growing electricity demand. A large reactor uses 150 tons of natural uranium each year, equivalent to 2 million tons of coal or 10 million barrels of oil. Uranium is a native resource, abundant and relatively inexpensive. Expanded use of nuclear power in the future will depend on its economic comparison with other fuel sources.

The nation has a tremendous economic investment in its operating nuclear reactors. However, the economics of replacing or adding electric generating capacity do not clearly favor nuclear power over coal. While both are less expensive fuel sources than oil, the differences in life cycle costs make nuclear and coal comparable. Lower fuel costs can compensate for the higher capital and operating cost of nuclear power. But most important, nuclear power plants, once in place, are well suited to providing a utility's base-load production (the typically 60 percent of demand that remains constant) because they run most efficiently at a constant, high level of output. The industry challenge is to overcome the institutional obstacles to building new nuclear generating capacity.

The environmental element of power generation is clearly one of marketable benefit to the nuclear industry. Oil, gas, and coal as fuel sources produce nitrous oxides and sulfur oxides which have been blamed for environmental deterioration such as acid rain and for global warming. Nuclear power generation produces none of these side effects. For the nuclear power industry to survive and prosper, it must exploit its environmental advantages and solve its waste management problems in cooperation with local, state and national government agencies.

Coal and other nonrenewable resources are not the only alternatives to nuclear power in meeting future energy demand. Utility regulators are changing their rules to reward utility

companies for reducing demand through conservation and efficiency improvements. New conservation technologies as well as continued development of wind and photovoltaic technologies may eventually compete economically with nuclear power. At least for the near term, the nuclear power industry is a major part of the nation's electricity generating infrastructure. Nuclear power has an undeniable role. The paralysis the industry now faces serves only to increase future costs.

**Energy Policy**

First, the National Energy Strategy of the United States appears to reflect a broad public opinion of the role of nuclear power. Public opinion recognizes the importance of nuclear power generation for future electricity requirements (Chart 4). The public even reluctantly agrees to the need for new power plants, while simultaneously wishing there were a better solution.

Second, the strategy recognizes the impact of not implementing a proactive nuclear energy policy. If the nuclear power industry continues to wither, utilities will phase out nearly all nuclear capacity by 2030 as licensed plants reach their design lives. Even an aggressive extension program over the next 20 years wouldn't stop the decline in nuclear capacity. In response, coal use could increase from 55 to 75 percent of total electrical generation, with its more hazardous environmental implications.

The specific actions called for by the National Energy Strategy related to nuclear power are:

- Establish a license renewal process for existing plants to prevent the premature loss of existing capacity.
- Reform the licensing process for new plants.
- Demonstrate an early site permit process by issuing an early site permit to a utility by 1995.
- Support Nuclear Regulatory Commission certification of two standard designs using passive safety features, with the goal of a first new plant operational by 2000.
- Fund research and development of advanced nuclear systems.
- Expedite initial operation of a monitored retrievable storage (MRS) facility to accept spent nuclear fuel by 1998.
- Expedite the characterization of the candidate repository site at Yucca Mountain, Nevada, and the operation of a high-level waste repository.

We support the actions of the National Energy Strategy as they address nuclear safety, environmental, economic, and waste problems. However, while we recognize the technology exists to meet many of the challenges, we see a lack of vigorous political support for and national acceptance of nuclear power, no national plan emphasizing types of energy, and no clear understanding of the total costs and benefits of alternative sources of energy. Without

strong federal leadership, the nation will continue to squander money in the areas of waste management and licensing new reactors. Current spending dictates the national plan. Nuclear power continues to be politically hamstrung by emotional concerns.

Along with policy statements, a coordinated effort to expand the use of nuclear power technology will require real progress in legislative, regulatory, economic, and political areas. A federal role is essential in overcoming the local and state "not in my backyard" syndrome. The nuclear power industry, from new generation reactors to waste management, will only survive if it promotes nuclear power as a national requirement. The executive branch must take a determined lead in pushing through institutional reforms and a national energy plan that gives nuclear energy the opportunity to compete economically with other energy alternatives.

**Improving the Licensing and Regulatory Process**

This issue is at the heart of making nuclear power economically competitive. The licensing process that evolved through the growth years of nuclear power plant construction reflected a utility industry that often did not know what it was getting into, couldn't control construction costs, had difficulty matching capacity with growth and demand, and customized designs with every construction project. The process became cumbersome, unpredictable, and subject to procedural delays and lengthy legal challenges. Construction times trebled between 1970 and 1990. Nuclear opponents were able to intervene at the operating license stage even after they had been unsuccessful in their opposition at the construction permit stage. Anti-nuclear sentiment created uncertainty in public rate-setting, sometimes leaving utilities incapable of recovering the full costs of their capital intensive nuclear investment. The regulatory processes are changing as shown in Chart 5.

Reforms are essential to:

- Ease new construction, not through less stringent standards, but by early resolution of technological and institutional issues before construction starts.
- Encourage standardized plant designs. The Nuclear Regulatory Commission Chairman, Ivan Selin, has noted that in France, which has a successful and popular noncontroversial nuclear power program, "there are 365 kinds of cheese and one kind of reactor. In the United States it's the opposite." Fewer designs reduce costs and construction times.
- Allow for pre-approved sites. This gives utilities an earlier view of the project's chances for economic success.
- Reduce the time permitted in post-construction hearings.
- Speed the proposed test of the license renewal process. Plans for replacing aging reactors are dependent on the outcome of this program.
- Combine the construction permit and operating license.
- Allow a fair return on the capital investment utilities need to provide electricity.

- Make regulator approvals binding and not subject to future political wrangling.

The results will start to put nuclear power on an even playing field with other power sources for economic comparisons. If economics favor nuclear power generation, a more predictable licensing process will give utilities and their investors the confidence to finance and build new power plants.

**Safety Concerns and Public Acceptance**

Perhaps at the root of nuclear power's long-term crisis is the public's lack of confidence in the industry. As in past years' observations, we continue to see a lack of public education on the subject of nuclear safety, a cultural mistrust of the government, and a lack of communication. There is no energy threat of crisis proportions to help galvanize public support for the nuclear power industry.

The goal of the industry in this area should be to acquaint the public with the industry's economic benefits and safety record. The industry has made steady and credible progress. Advertised reliability, as shown by plant performance factors, continues to improve. The U.S. average nuclear capacity factor exceeded 62 percent for the third consecutive year in 1990. This rate is 10 percentage points higher than 10 years ago. The industry reduced the number of unplanned shutdowns (reflecting operator error or equipment failure). The industry learned much from the Three Mile Island accident (an economic and public perception disaster, but not a safety disaster). Operator training and control room informational display deficiencies resulted in many NRC-mandated changes. Beginning this year, every nuclear power operator has access to a simulator like the $18 million Three Mile Island mockup of the power plant control room. Power plant sites have started community monitoring programs to measure if any radioactive materials are being released from the plants. All these actions help demonstrate the industry's reliability record and concern for safety.

There is much more to accomplish in public relations to improve the public's perception of nuclear power, to include:

- Emphasizing strong occupational safety and environmental monitoring programs.

- Advertising the differences between U..S and Russian and Eastern Europe reactor designs (ours are safer).

- Publicizing the benefits of new generation reactor designs such as passive safety characteristics, lower operational temperatures, and redundant containment features.

- Promoting power plant visitor centers.

- Learning from the public education elements of successful nuclear programs in the United Kingdom and France (the Visitor Center at Sellafield, England is a good example of outreach and community relations).

Even with the best of public relations programs showing that nuclear plants are operating well, the industry will remain tenuously close to the next disaster in public confi-

dence. Technological improvements will continue. The Nuclear Regulatory Commission and public utility commissions can make sound economic decisions, but the industry's public relations posture will continue to have strong "damage control" elements. Energy and environmental concerns surrounding non-nuclear power sources--not yet of crisis proportions in the public view--will not be strong enough to protect the industry from latent public safety concerns.

**The Industrial Base**

The industrial base for domestic nuclear power plant production has peaked. With no new orders, the base for current technology will be non-existent. Projections through 2010 show essentially no growth in Europe and in other regions now using nuclear power. The Far East shows a moderate regional growth, but is weak in terms of an ability to sustain the industry.

The United States supports technology transfer for new energy production reactors. It is competitive in critical technologies and processes and in developing second generation nuclear energy technology (that is, designs with potential for commercial applications within the next 30 years). The second generation technology includes a myriad of evolutionary and advanced reactor concepts featuring simple designs, small sizes (to keep them economical), and increased safety through limited reliance on human and mechanical safety systems.

However, there is a shortage of interested buyers in the developed countries and, though the need may exist in developing countries, the financial requirements for nuclear energy are still overwhelming. There are also concerns about exporting nuclear technology, but any linkage between nuclear power production and weapons production is limited by international safeguards inspections, the vastly different processes needed to produce electricity and fissile material needed for an explosive, and the higher costs of trying to develop weapons from a civil program. Despite these limitations, we would not suggest a wholesale marketing of nuclear power technology to (a) countries with no nuclear experience, (b) unstable regions subject to political unrest and exploitation, or (c) countries with infrastructure (such as power plants and transmission lines) vulnerable to terrorist attacks.

Therefore, the best long-term opportunity for industry growth is in the area of smaller, simpler, and standardized power plant designs. US efforts in this regard should be directed towards stable countries with successful programs that have potentially fewer regulatory and public acceptance concerns than the United States. Otherwise, the industry will be fortunate to sustain an adequate research and development base while it addresses its domestic political, economic, and regulatory issues.

**Lessons from France and the United Kingdom**

***France***

The French nuclear power industry has an enviable record of growth and a healthy forecast. The French success has depended on a centralized political system, a regulatory system that emphasizes technical, not legal, resolution of issues, a national commitment to energy security, and a long-term outlook on the need for and growth of the nuclear industry.

France uses a standard design pressurized water reactor, developed and manufactured by a French supplier. It is based on a Westinghouse design and, with few design changes from the late 1960s to the early 1980s, this standardization has helped keep costs of building and operating power plants lower than in the United States. The average time to build a nuclear unit was less than 6 years through the 1980s. While construction time had increased to almost 8 years by 1990, it is still only half the time projected in the United States.

Nuclear power supplies 75 percent of France's electricity and while the French expect capacity to increase slightly over the next 20 years, the nuclear share of electricity will remain at about 75 percent. Four new units are under construction with seven more announced and under design.

The success of the French nuclear power program has allowed them to build capacity for export. France sells 10 to 15 percent of its electricity to the United Kingdom, Switzerland, and Italy. Spain in 1993 and Portugal in 1994 will also begin receiving French power through long-term contracts. France is also involved with reactor construction projects in Hungary, Pakistan, and Taiwan, and joint ventures with Belgian, British, German, and Spanish utilities to develop advanced reactor designs.

Perhaps most impressive is the French expertise in all stages of the nuclear fuel cycle, particularly resulting in their commitment to spent-fuel reprocessing. The La Hague reprocessing plant, which we visited, recovers 97 percent of the uranium and plutonium from spent fuel for recycling. (This reprocessed plutonium is not weapons grade and does not add concern for proliferation; it can be used as a nuclear fuel.) This process helps ensure fuel self-sufficiency, reduces the amount of waste from utility plants, and generates international revenue by reprocessing spent fuel from utility plants in Belgium, Germany, Holland, Japan, and Switzerland. France has also emphasized a life-cycle approach to reactor operations by putting money into a decommissioning fund for their reactors.

The French nuclear power program is not without its problems. They face considerable decommissioning and dismantlement costs for reactors with licenses that started expiring in 1985. Recent design problems have delayed the construction time of at least one new reactor. Problems have plagued their breeder reactor development program. Their reprocessing program has resulted in an excess of plutonium. France faces the same difficulties as the United States in finding a permanent waste repository, but they have created a vitrification process (mixing high-level waste with molten glass) to store high-level waste above ground safely for the next thirty to fifty years. The French have also achieved a consensus to build new reactors at current nuclear sites without new hearings or other regulatory constraints. Despite the challenges it faces, the French program has much to show the United States in terms of national political, economic, and popular support.

***The United Kingdom***

The British nuclear energy industry faces many of the problems faced by the U.S. nuclear industry. The United Kingdom must weigh the marginal economies of nuclear energy production against the value of having diverse energy sources and the environmental concerns of other fuel sources. Political parties in opposition to the government have been challenging the construction of new reactors as well as plant life extension proposals. New

construction could resume if British Nuclear Fuels, the operator of many nuclear units in England, can generate electricity economically. The operator in turn tries to advertise nuclear power generation as a more appropriate long-term energy source for electricity than potentially constrained natural gas reserves.

The industry is still grappling with the design of future reactors. Alternatives include an advanced light-water reactor, improving existing light-water reactors, or developing a European advanced reactor design.

The nuclear industry in the United Kingdom provides fuel manufacturing, enrichment, and reprocessing for foreign customers. But a worldwide overcapacity of uranium has hurt the business element, resulting in international competition, depressed prices, and labor reductions in the United Kingdom. They also compete for reprocessing contracts with French companies. Britain's reactor decommissioning activities have been rewarded by a DoE contract with British Nuclear Fuels to assist in the cleanup of the Hanford site.

Like France, the United Kingdom reprocesses its own spent fuel. It has reprocessed 80 percent of its uranium. Reprocessing started for military purposes, but continues as a way to maintain a secure source of uranium, reduce waste, and generate foreign income.

The United Kingdom has 37 reactors, with one under construction and due to open in 1994. Any new construction afterward will depend on demonstrating that nuclear power plants can generate electricity competitively. The nuclear share of electricity generation is 20 percent but projections show continuing political and public support problems. It also faces the challenges of finding a deep underground repository for waste and the costs of decommissioning reactors, a process that started in 1988.

## ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT

### Environmental Restoration

DoE is responsible for waste management and cleanup of more than 100 contaminated installations in 36 States and territories. In 1989, DoE established a 30 year goal to clean up and restore the environment at its nuclear sites through the performance of environmental restoration, waste operations, and transportation of DoE wastes.

While the DoE budget for environmental restoration and waste management (EM) activities has tripled during the past three years, it is not realistic to assume this rate of growth will be maintained. The total estimate for environmental restoration and waste management activities for FY 1994 is $6.1 billion, and it is reasonable to assume a growth of between five and ten percent per year for FY 94-98. Developing planning estimates for EM requires an accurate vision of future technical requirements for environmental restoration and for waste treatment, storage and disposal.

The environmental task facing DoE is enormous and continues to expand. DoE has approximately 4,000 contaminated sites covering tens of thousands of acres and replete with contaminated hazardous or radioactive waste, soil, or structures. It has more than 250,000

cubic meters of transuranic waste and millions of cubic meters of low-level radioactive waste. In addition, DoE is responsible for thousands of facilities awaiting decontamination, decommissioning, and dismantling.

The DoE faces major technical, planning, and institutional challenges in meeting its expanding environmental responsibilities while controlling cost growth. Among these challenges are:

- developing technically sound, cost-effective technologies to apply to cleanup and waste management problems;

- establishing a risk management strategy that is acceptable to regulators and the public;

- developing a consensus on the ultimate use of DoE sites and facilities;

- meeting worker health and safety needs; and

- managing the facility transfer process.

DoE's environmental restoration program faces several perceived and anticipated obstacles to accomplishing its mission and fulfilling its objectives:

- The current regulatory environment includes potentially conflicting and unclear regulations. It offers little, if any, incentive for the adoption of new and innovative technologies for cleanup or allowance for their development and testing as part of the cleanup process.

- The program needs to move from an environment of addressing day-to-day emergencies to one of long-term planning and progress to minimize program inconsistencies.

- Beyond funding issues, the program is faced with a lack of infrastructure to accomplish its task and must address laboratory, personnel, and technology resource constraints.

- Occasionally public misunderstanding of the nature of the waste and environmental management disposal techniques can delay environmental restoration progress.

- The environmental restoration program must work closely with the technology development program to develop the appropriate characterization and treatment technologies. Technology transfer must be expedited to prevent delays. Delays must also be prevented in the regulatory approval process for new technologies.

- The program may face unexpected outcomes from site assessments and technology development, a changing regulatory environment, and inconsistent public priorities. Contingency planning to understand the impacts of these uncertainties must be performed.

• A program of working with communities and environmental groups is needed.

The scope and magnitude of the environmental restoration effort may be greater than DoE alone is capable of dealing with. If so, the Congress may wish to consider establishing a separate federal program for environmental restoration under the control of an independent agency, possibly within the Executive Office of the President. Unlike the DoE, this "Office of Environmental Restoration" could devote its complete attention to execution of the significant task at hand.

**The Waste Management Problem**

***Low-Level Waste***

Low-level waste includes all radioactive waste not classified as either high-level waste, transuranic waste, spent nuclear fuel or the bulk of the by-product tailings containing uranium or thorium from processed ore.

DoE low-level waste is generated at more than 30 different sites and is disposed of at six sites: Savannah River, Oak Ridge, Idaho National Engineering Laboratory, Nevada Test Site, Los Alamos National Laboratory, and Hanford. Low-level waste is disposed of by near-surface burial. During the past ten years, approximately 100,000 cubic meters of low-level waste have had to be disposed of per year. Improved treatment methods are being developed to reduce waste volumes requiring disposal and to provide stable waste forms.

Public Law 96-573, the Low-Level Radioactive Waste Policy Act, specifically assigned states the responsibility for providing for disposal of all low-level waste generated within their borders. At present, Washington, Nevada and South Carolina host commercial low-level waste disposal sites, although the latter two have announced plans to close their facilities. The Low-Level Radioactive Waste Policy Amendments Act of 1985 (Public Law 99-240) further clarified state's responsibilities for the disposal of commercial low-level waste generated within their borders and encouraged the formation of regional compacts.

***Transuranic (TRU) Waste***

TRU is defined as waste contaminated with alpha-emitting radionuclides with an atomic number greater than 92 (heavier than uranium), half-lives greater than 20 years, and in concentrations greater than 100 nanocuries per gram of waste. The principal sources of TRU waste are research and development, plutonium recovery, weapons manufacturing, and decontamination and decommissioning. Although most TRU waste is no more radioactive than many low-level wastes, the long duration of its radioactivity puts it into this special category.

Currently, DoE manages approximately 251,400 cubic meters of TRU waste and five million curies of radioactivity. Approximately 60,607 cubic meters of this total has been generated since 1970. All TRU waste generated since 1970 has been placed in long-term storage at six DoE sites. The waste is stored in retrievable form for eventual shipment and disposal at a permanent geologic repository.

TRU waste is contained in a variety of packagings, including metal drums and wooden and metal boxes, and is stored in earth-mounded berms, concrete culverts, or other types of facilities. It is estimated that 72 percent of the drums have been in storage for more than ten years and 20 to 30 percent of the bermed drums contain corrosion pinholes or are badly deteriorated. Repackaging and relocating some waste will be required before shipment.

The Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico, was constructed as a research and development facility to demonstrate safe disposal of retrievable, stored defense program waste in a geologic repository. Public Law 96-164, Department of Energy National Security and Military Applications of Nuclear Energy Authorization Act of 1980, appropriated funds for the WIPP activities and defined the project's mission. In an effort to reduce uncertainty in the prediction of long-term repository performance, a multi-year test phase using a limited amount of radioactive waste is planned. If compliance with EPA regulations can be demonstrated, WIPP will be used for disposal of TRU waste currently stored in Idaho, Colorado, Washington, South Carolina, Tennessee and other states. The earliest date that DoE can begin the first test phase, assuming that all statutory prerequisites are met, is August 1993

### High-Level Waste (HLW)

HLW is highly radioactive waste material that results from the reprocessing of spent nuclear fuel or from defense production processes. It includes liquid waste produced directly in reprocessing and highly radioactive solid waste derived from that liquid. Some HLW contains elements that decay very slowly and remain radioactive for thousands of years. Most HLW must be handled by remote control from behind protective shielding. Spent fuel from nuclear power plants, which is also classified as HLW, is currently the management responsibility of the DoE Office of Civilian Radioactive Waste Management (OCRWM).

High-level waste generated by DoE's nuclear weapons complex activities is stored in underground and above-ground storage tanks at the Savannah River Site, Idaho National Engineering Laboratory, and the Hanford Site. The total high-level waste volume of about 381,000 cubic meters stored at these sites contains some 1.1 billion curies of radionuclides. The condition of many of these storage tanks is less than desirable, and the potential for environmental damage is significant.

Over 21,800 metric tons of spent fuel from commercial nuclear reactors had accumulated "onsite" by the year 1990. It is projected that over 40,000 metric tons of spent fuel will have accumulated by the year 2000, and this fuel will contain an estimated $3 \times 10^{10}$ curies. By 2035, after all existing nuclear power plants have completed forty years of operation, there will be approximately 85,000 metric tons of spent nuclear fuel requiring disposal.

Although legislation addressing the disposal of high-level nuclear waste was passed in 1982 (Public Law 97-425), no approved disposal site for commercial or defense high-level nuclear waste currently exists. If the United States cannot solve its high-level nuclear waste disposal problem, both the future of the nuclear power industry and the welfare of both present and future generations of our citizenry are in jeopardy. Resolving the high-level nuclear waste disposal problem is a matter of national interest.

## Current HLW Disposal Policy

The current policy toward disposal of HLW is to utilize deep geological isolation in a combined natural and engineered repository (Nuclear Waste Policy Act (NWPA) of 1982 as amended in 1987 (P.L. 100-203)). The DoE continues to work toward completion of site characterization at Yucca Mountain, having already spent in excess of $1 billion in site-related work and projecting an additional $6 billion in expenditures to get to completion and submission of license application, assuming that the site is found suitable. Due to existing legislation, there are no alternative repository sites under consideration, should Yucca Mountain be deemed unsuitable.

The Nuclear Waste Negotiator continues to search for parties interested in hosting a Monitored Retrievable Storage (MRS) facility. His office has had a total of twenty applicants to date, six of which remain active. Counties that have attempted to progress in the negotiation process have been prohibited from further involvement by their state governments. All active applicants are Indian Tribes located on sovereign territory in New Mexico, Utah, Oklahoma (2), Minnesota, and Oregon.

Although selection of an MRS site is linked statutorily to DoE approval of a repository site, the former Secretary of Energy stated in a letter to the Chairman of Minnesota's Northern States Power Company that DoE's schedule called for having an MRS operating by 1998 in order to begin receipt of spent nuclear fuel. He stated that a permanent repository would commence operation within six years of completion of US Nuclear Regulatory Commission (NRC) reviews of the repository license application, and that DoE expected to start receiving spent fuel at the repository in 2010. It is uncertain if the current Secretary will adhere to that prediction. In the interim, spent nuclear fuel remains in storage onsite at the reactor facilities. DoE defense program liquid HLW will be vitrified in order to comply with the NWPA requirement to store HLW in a durable, solid form. Solidified HLW from the defense programs will total approximately 8,000 metric tons.

## Cutting Edge Issues

The cutting edge issue associated with the problem of disposal of high-level nuclear waste is, essentially:

Should the United States commit to permanent deep geological storage of HLW as the most appropriate disposal method, or should it delay that decision for the development of future technologies that will provide a safer, more effective and more efficient means of disposal?

If geologic disposal is determined to be the most appropriate method, and the nuclear generation of electricity remains a part of our National Energy Strategy, then an associated issue that must be addressed is:

Should the United States reprocess spent nuclear fuel in order to permit the conservation of natural uranium resources and significantly reduce the volume of high-level waste requiring disposal?

**Recommended HLW Disposal Policy**

The Nuclear Industry group recommends delaying the siting of the permanent repository and continued interim onsite storage. This policy option recognizes that our scientific knowledge is continually expanding; it capitalizes on the increased potential for the discovery of a safer, more efficient and effective method of disposing of HLW; it recognizes the issues of state's rights and the importance of public support of policy; and it moves to correct past injustices in both areas. Although delayed siting with interim c ısite storage is costly, the potential costs of a nuclear environmental catastrophe brought on by hasty decision-making at the Yucca site are far greater.

This alternative would suspend site characterization of Yucca Mountain and delay the development of a permanent geological repository for a period of at least twenty to thirty years. During that time, DoE should undertake a program of evaluation of potential geological repository sites similar to that originally intended in the NWPA. Increased emphasis would be placed in research and development of processes such as the transmutation of waste and technologies such as the Integral Fast Reactor (IFR). Research in other methods of disposal such as deep seabed burial would also be aggressively explored.

In the interim period, spent fuel would continue to be stored onsite using water pools, dry cask storage or some similar method. The NRC has certified dry cask storage as being safe for between 120 and 150 years. Costs associated with onsite storage after 1998 would be defrayed by federal subsidies to the affected nuclear utilities. The WIPP could be used as an interim storage facility for the HLW of plants that are no longer capable of onsite storage. Use of WIPP as an MRS facility was originally described by the House Committee on Insular Affairs in action leading to the passage of the NWPA of 1982.

Implementation of this alternative will require legislation causing the suspension of characterization of the Yucca site, or scaling back of characterization activities at Yucca consistent with those at other potential sites. Public involvement and participation in the site selection is essential, and the Federal Government can not force a site on someone under this policy alternative as it did with Yucca Mountain under the current policy.

Interim storage onsite is well within our current capability, and can be accomplished safely for a period in excess of 100 years. The sealed casks used for above-ground storage cost about $2 million each, in addition to the cost of monitoring and guarding them. Subsidizing the associated storage costs after 1998 with Nuclear Waste Fund (NWF) trust fund monies will reduce the burden of "double payment" on the ratepayers, and partially fulfill the government's commitment to accept responsibility for HLW. Like the previous alternative, the WIPP could serve as an interim storage facility for spent fuel from plants no longer capable of onsite storage. Many nuclear plants, such as Three Mile Island, possess the onsite capacity for spent fuel storage through the expiration of their current 40-year operating license.

The greatest benefit of adopting this alternative is that it restores equity and fairness to the nuclear waste management process; as a consequence it serves to restore the public trust in DoE and promote greater understanding of the entire nuclear program. Politically, it is a difficult alternative due to the amount of time and money already invested in Yucca Mountain under the current policy. However, a failure to qualify the Yucca site, or to find willing MRS

facility hosts, will greatly increase the political feasibility of this alternative policy.

By not proceeding too quickly with the deep geological repository, we avoid decisions that may be costly to correct in the future. Delaying repository construction and expanding the site selection process, however, will increase costs encountered in the present. A key assumption of this alternative is that technological advances may occur over the next several decades that could significantly alter our methods of handling nuclear wastes (i.e., transmutation, IFR burning, etc.). By not prematurely committing to permanent geological disposal, this alternative policy option can capitalize on those technological advances. In so doing, this alternative will also effectively address the issues of intergenerational equity and effectiveness.

This option recognizes that our scientific knowledge is continually expanding, and it capitalizes on the increased potential for the discovery of a more efficient and effective method of disposing of HLW. The public trust in both DoE and the Federal Government was severely damaged by the forcing of the Yucca site on the State of Nevada. This option recognizes the issues of states' rights and the importance of public support of policy, and it moves to correct past injustices in each of these areas.

Although delayed siting with interim onsite storage is a costly option, the potential costs of a nuclear environmental catastrophe brought on by hasty decision-making at the Yucca site are far greater. It is in the national interest, for this and future generations, to resolve the problems of HLW disposal in a manner that is reasonably safe, effective and equitable. Delayed siting of the permanent repository with interim onsite storage is a policy alternative well suited to satisfy those criteria.

### Reprocessing of Spent Nuclear Fuel

After producing energy for several years, spent fuel is unloaded from the reactor. This fuel contains recoverable materials (uranium and plutonium) that can also be used to produce energy, and non-recyclable wastes (mainly fission products and metal fuel cladding segments). Reprocessing technology allows for the recovery of 97 percent of the energy producing materials from spent fuel (96% uranium and 1% plutonium). Using these materials to manufacture new fuel assemblies permits the conservation of natural resources. After reprocessing, the fission products, metal fuel claddings and the wastes generated during plant operation are packaged in an appropriate form for final disposal.

The United States, under President Carter, chose to dispose of spent nuclear fuel without reprocessing. This policy was initiated due to fears of proliferation and terrorism, because plutonium is a by-product of reprocessing. Today, the decision not to reprocess is espoused to be an economic one, in that it is claimed to be cheaper to mine and process uranium ore than it is to reprocess spent fuel. This means that each 1,000 megawatt nuclear power plant will continue to produce approximately 30 tons of spent fuel each year. If reprocessed, 28.8 tons could be recovered as reusable uranium and another .3 tons as plutonium. The remaining .9 tons would remain as HLW requiring disposal, a significant reduction from the original 30 tons.

The United States should reverse its decision not to reprocess spent fuel on the basis of waste minimization and resource conservation. The consequences of such an approach would be to reduce the estimated 40,000 tons of spent fuel projected to accumulate as HLW by the year 2000 to 1,200 tons of actual high-level waste requiring disposal. The issue of plutonium proliferation can be addressed by either stockpiling it or returning it to nuclear power plants as mixed oxide (MOX) fuel (uranium/plutonium mix).

## CONCLUSIONS AND RECOMMENDATIONS

### Nuclear Weapons

In the absence of any revived threat, the U.S. nuclear weapons industry faces a continuing decline. With no new warheads in design or production, the only work remaining is maintenance and improvement (for safety and reliability) of the current stockpile, dismantling warheads, and participation in verification of compliance with arms control treaties and nuclear non-proliferation. Specific conclusions include:

- There is considerable excess capacity in the nuclear weapons complex; the Complex 21 plan contains proposals to reduce this excess.

- Weapons dismantling and stockpile maintenance and improvements will continue to occupy a portion of the weapon complex facilities.

- Tritium recapture from dismantling will provide sufficient tritium for roughly the next twenty years at currently planned stockpile levels, but a new source of tritium will be needed to maintain the stockpile beyond 2013.

- Sufficient capability will remain in the national laboratories and scaled-down weapons complex facilities under the Complex 21 plan to reconstitute warhead manufacturing on a small scale.

- The weapons complex national laboratories constitute a national asset that can be utilized beyond their original nuclear mission by commercial firms through technology transfer and cooperative R&D.

- Nuclear treaties reducing the weapons inventories are making a valuable contribution to the "New World Order," but verification of compliance and early warning of possible breakouts from these treaties are vital.

- Nuclear non-proliferation and counter-proliferation are fundamental U.S. national security concerns.

- The International Atomic Energy Agency's (IAEA) mission of preventing the diversion of materials from peaceful uses of atomic energy to weapons programs needs continued U.S. support.

**Recommendations:**

We provide the following recommendations to address key decisions that must be made regarding the future of the weapons industry:

1. The proposals contained in DoE's Complex 21 plan to consolidate non-nuclear manufacturing at the Kansas City Plant and to close and clean up Rocky Flats, Hanford and Savannah River should be implemented.

2. An alternative source of tritium should be developed so that it will be available when needed in 2013.

3. The weapons complex national laboratories' programs to expand cooperation with industry in non-nuclear areas should be encouraged and expanded. Federal support to the current number and size of laboratories for the sole purpose of maintaining nuclear capabilities is not recommended.

4. Verification of compliance with international treaties reducing the nuclear weapons inventories is vital; a robust intelligence capability is essential and should be supported by the administration and by Congress.

5. Should there not be a Comprehensive Test Ban by 1996, future nuclear weapons tests should remain a US option, but only tests directly related to the safety or safety-related improvements of the stockpile. Similar strictures should apply to tests by Britain at U.S. facilities.

6. U.S. support for the IAEA in the area of nuclear non-proliferation should be increased in both money and manpower. Similarly, additional funding and personnel for the Arms Control and Disarmament Agency to enhance their non-proliferation activities should be provided.

7. U.S. support for the former Soviet Union states in eliminating their nuclear weapons in compliance with treaties, in cleaning up their nuclear wastes, and in keeping their nuclear scientists and engineers employed is encouraged.

**Nuclear Power**

The nuclear power industry faces serious challenges if it is to survive as a long-term source of electrical power in the United States:

- Nuclear power is expected to remain an important component of our electrical generation capacity well into the 21st century.

- The National Energy Strategy recognizes the importance of nuclear energy and should be the primary document for promoting measures that allow nuclear power to compete on an economical basis with other energy alternatives.

- The primary industry challenge is to overcome institutional obstacles to building new

nuclear power generating capacity.

- Changes to the regulatory and licensing process are essential to give utility companies and their investors the confidence to consider building new nuclear capacity.

- Safety issues and the lack of crisis-proportion concerns over supplies and environmental impacts of other energy sources will continue to keep nuclear power from gaining complete public acceptance.

- Without industrial base growth, the industry may have difficulty sustaining itself with a trained work force, and the operations and maintenance budgets needed to generate power safely and efficiently.

- Without institutional changes, the only opportunity for domestic nuclear industrial base growth will be through export of existing technology to developing countries or by significant progress on second generation nuclear technology.

**Recommendations:**

We provide the following recommendations in an effort to address the political, economic, regulatory, and public support problems confronting the nuclear power industry:

1. Publicly exploit the environmental and fuel self-sufficiency advantages of nuclear power.

2. Strengthen political support for the National Energy Strategy by emphasizing a long-term approach to build and operate nuclear reactors, conduct research and development, and improve safety and public acceptance.

3. Speed the licensing and regulatory reform process to better allow nuclear power generation to compete on an economic basis with other energy sources. Facilitate relicensing of existing plants. Stabilize the licensing process and use one-step licensing. Use standardized plant designs. Eliminate overly-restrictive barriers to the use of nuclear power.

4. Readdress the U.S. decision not to reprocess spent nuclear fuel. Unless the cost and environmental aspects are overwhelmingly negative, the positive effect of reprocessing on waste disposal problems, and the absence of evidence of nuclear proliferation hazards from reprocessing, appears to justify a reversal of this decision.

5. Support nuclear power technology exports to foreign countries on a limited basis with strict controls on further re-exports or use of the technology.

6. Apply lessons of the successful public relations and education programs of France and the United Kingdom to improve acceptance of nuclear power technology.

**Nuclear Waste**

Without strong leadership and investment in new technology, the nuclear waste

"legacy" of both the weapons and energy programs will continue to grow and affect public acceptance of continued operation of nuclear facilities. Our conclusions in this area are:

- Lack of progress on waste management and environmental restoration, particularly on long-term storage of all types of waste, threatens the power industry's long-term credibility as a safe and environmentally responsible alternative to other forms of energy.

- New technologies hold promise for reducing the amount of waste to be stored and making better use of the energy remaining in spent fuel or weapons materials.

- Efforts to date by DoE and the states to find solutions to the waste management problem have been generally unsuccessful and highly controversial.

- Reprocessing of spent fuel in England and France reduces the volume of material to be disposed of by 97%, but produces plutonium.

**Recommendations:**

1. Pursue opening the Waste Isolation Pilot Plant (WIPP) as soon as all regulatory hurdles can be overcome.

2. Invest in technologies, such as new reactor types that burn spent fuel from existing plants, that will eliminate some of the existing waste.

3. Delay siting the permanent high level waste repository, currently planned for Yucca Mountain, NV, until further exploration of technological solutions to the waste problem can be completed. Continue on-site interim storage at nuclear power plants and weapons complex sites. Explore use of the WIPP as a high level waste monitored retrievable storage (MRS) site on an as-needed basis.

4. Continue to search for MRS waste sites, but ensure all issues of equity, states' rights, and citizen involvement are addressed in the process.

5. Reassess reprocessing spent nuclear reactor fuel as discussed in the nuclear power section above. Existing safeguards should be adequate to ensure plutonium from U.S. reprocessing is handled in accordance with IAEA rules and kept out of the hands of terrorists or nuclear " wannabe" states. If nuclear power is to remain an important component of our electrical generation capacity, reprocessing would greatly reduce demand for continued uranium mining and processing and improve our ability to handle the waste from spent fuel.

6. The success of DoE in developing a comprehensive program for environmental restoration and waste management should be closely monitored by the Federal, state and local governments. If reasonable progress is not made, consideration should be given to establishing a separate Federal agency to develop and manage this program.

The United States must solve today's problems in the nuclear weapons and nuclear power industries. The U.S. security and economic health depends upon it. If the United

States is to remain a responsible member of the world's nuclear club and have nuclear power in the next century, it must face the problems today and work to address them. The United States will need strong government leadership, both by the President and the Congress, and strong public relations programs by the utilities to tackle the obstacles the industry faces.

# INDUSTRY STUDIES

# # 4

# ENERGY

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## PLACES VISITED

### Energy-related Companies and Facilities

| | |
|---|---|
| ARCO Marine, Inc. | Long Beach, California |
| CALTEX Pacific Ltd | Duri, Sumatra, Indonesia |
| CALTEX Steam Injection Field | Duri, Sumatra, Indonesia |
| CALTEX Power Generation and Transmission Division | Duri, Sumatra, Indonesia |
| Chevron Corporation | San Francisco, California |
| Chevron Refinery | El Segundo, California |
| KJC Operating Company and solar energy generating station | Boron, California |
| Mobil Asia Pacific, Private Ltd. | Singapore |
| M/V ARCO Spirit (Tanker) | Long Beach, California |
| Singapore Refining Company Refinery | Jurong, Singapore |
| Solarex Corporation | Frederick, Maryland |
| Southern California Natural Gas | Los Angeles, California |

### Government Organizations

| | |
|---|---|
| California Energy Commission | Sacramento, California |
| Center for Research and Technology (PUSPIPTEK) | Serpong, Java, Indonesia |
| Central Intelligence Agency | McLean, Virginia |
| Defense Contract Management Office | Sembawang, Singapore |
| Defense Fuel Supply Center | Alexandria, Virginia |
| Economic Development Board, Ministry of Trade and Industry | Singapore |
| Institute for National Defense (LEMHANNAS) | Jakarta, Indonesia |
| Ministry of Environment | Singapore |
| Ministry of Mines and Energy | Jakarta, Indonesia |
| Port of Singapore Authority | Singapore |
| Sacramento Municipal Utility District | Sacramento, California |
| U.S. Department of Energy | Washington, D. C. |
| U.S. Embassy Country Team | Jakarta, Indonesia |
| U.S. Navy, Commander, Logistics Western Pacific | Sembawang, Singapore |
| U.S. Navy Supply Center and Red Hill Fuel Storage Facility | Pearl Harbor, Hawaii |

### Industry and Non-Governmental Organizations

| | |
|---|---|
| American Gas Association | Washington, D. C. |
| American Petroleum Institute | Washington, D. C. |
| American Wind Energy Association | Techachipi, California |
| Center for Strategic and International Studies | Jakarta, Indonesia |
| East-West Center | Honolulu, Hawaii |
| National Coal Association | Washington, D. C. |
| New York Mercantile Exchange | New York, New York |

## INTRODUCTION

In 1993, Defense Industry Study #4 was expanded from its previous focus on fossil fuels to include all aspects of energy except nuclear power. This change has produced a challenging area of study, and made energy unique among the various industries studied at the Industrial College of the Armed Forces. Energy in some form is an element of virtually every element of economic activity and, as the lifeblood of the economy, pervades every industrial sector. Indeed, energy can be labeled an industry only in the very loosest sense of the word. It is more accurately a collection of many diverse industries that compete, overlap and complement each other.

Because of the diversity of energy-related industries, this report will examine the principal energy sectors--petroleum, natural gas, renewable sources and coal--separately. Each sector will be analyzed in terms of its structure, conduct, performance and associated policy issues. A brief outlook section will attempt to synthesize general trends across the spectrum of the energy industry. A final section of the report will discuss some general policy issues and recommendations.

## ENERGY SECTOR: NATURAL GAS

Back in the "good old days" of the Arab oil embargo, people scrambled for new fuels and miracle ways to respond to the sudden scarcity and skyrocketing prices of gasoline (crude oil). Natural gas appeared to be the choice as an alternative fuel with potential to more than supplement the need and use of oil. Natural gas potential has never been fully realized.

Today, a newly formulated National Energy Strategy and accompanying congressional legislation recognizes that natural gas can play a much greater role in meeting our energy and environmental needs. Eliminating all price controls on natural gas at the wellhead, changing the way natural gas transportation and delivery services are conducted and priced, and increasing investment in natural gas research--these will help attain maximum advantage from ample supplies of natural gas well into the 21st century.

One inescapable fact is that natural gas is a depleting energy source. While this is not a "rocket scientist" revelation, preoccupation with the depleting nature of natural gas reserves has been a limiting factor on the expansion of the industry. This preoccupation has had two major stifling effects: (1) it has shortened the normal maturity from thirty to twenty years for amortization of capital investment; and (2) increased the need for long-term contracts between suppliers and purchasers because of heavy fixed investment for transmission capability.

### What's so great about the natural gas commodity?

From the wellhead to the point of use, natural gas enjoys a significant economic advantage over oil. U.S. natural gas resources are more plentiful than those of oil. The first-time recovery rate for natural gas wells is 70-80%, compared with 15-25% for oil wells. Natural gas can be utilized essentially the way it comes out of the ground, while oil has to be refined into various usable products. For the consumer, natural gas is always available at the turn of a switch. Consumers only pay for what gas they use; whereas, oil has to be ordered and paid for in advance of use. Oil also involves storage on the user's premises. Because gas burns cleaner than oil, it is an environmentalist's dream, and it has lower equipment maintenance expenses.

The following major trends favor the increased use of natural gas: (1) positive outlook for gas supply; (2) reasonable price prospects; (3) environmental advantages; (4) potential new technologies and applications: notably gas cooling, co-generation and transportation; (5) deregulation provides comparative advantages over competing energy sources; (6) worldwide growth of gas use and production; and, (7) natural gas can strengthen energy security by reducing excessive dependence on oil imports.

### STRUCTURE

The natural gas industry has three distinct segments. The first is the exploration and production of natural gas, which includes the processing and treatment of natural gas where it is produced. Treatment is usually necessary in order to provide a gas of appropriate quality that standardizes its burn characteristics among the many fields and also makes it suitable for transporting. These activities are undertaken by several thousand small, independent

producers and by most of the major oil companies.

The second segment is the transmission of gas by pipeline, either intrastate and/or interstate. Gas transportation by pipeline is the main business of most transmission companies. A typical small pipeline company in this segment is quite large in comparison to the many small production companies. Interstate pipeline companies are the most heavily regulated segment of the natural gas industry. Not surprisingly, the growth rate for new pipelines in this country slowed considerably after the peak year of 1975, due to regulation, investment cost and environmental reasons.

The transportation segment also includes a number of companies who have become involved in the newest form of gas transportation, the trans-ocean movement of liquified natural gas (LNG) by specialized ships. Importation quotas, safety, and environmental concerns still loom over the expansion of this element of the transportation segment.

The third segment is distribution. Although there are direct sales of gas from producers or transmission companies to large consumers, the small distribution companies ultimately sell gas to commercial, domestic, and small industrial end users. There are roughly 1700 distribution companies, a third are publicly owned and the others privately held. Many distribution companies are also combination utilities, selling not only gas but electricity as well.

### Concentration

Because of the evolution of the natural gas industry into three segments, most companies remain within one segment. The natural gas industry is mostly horizontally aligned, as opposed to the oil industry which has considerable vertical integration and relatively fewer, but larger corporation conglomerates.

### Entry Barriers

Each of the segments of the natural gas industry has its unique entry costs. he exploration and production phase has only recently evolved to become complicated as well as expensive. Initially, gas production was an unwanted by-product of oil production. As some of the original co-located natural gas fields were depleted, the cost of exploration and production began to rise. New techniques, such as deep drilling and offshore drilling, provided the means to attain natural gas, but they did not drive down the costs. Since predictions are for increased reliance on natural gas, major oil and gas producing companies will eventually put greater emphasis on this segment.

Even when there is a lot of natural gas to be found, development of the transmission infrastructure faces significant hurdles. The costs of large diameter pipelines are great, ranging considerably upward from $100,000 per mile. This does not include the environmental and regulatory concerns and their associated costs. While significant pipeline and local distribution networks developed in the major industrialized nations between 1950 and the early 1970s, the infrastructure that was in place at the peak of building (1975) is essentially what remains today. An additional piece of the transportation segment is the underground storage facilities close to the market areas. This element is environmental and

regulatory pressure and, thus, will also result in cost increases to the end-user.

For many years, the transportation and distribution segments have been considered as natural monopolies. The transportation segment felt the brunt of this perception with the heaviest regulatory considerations. The distribution segment, however, has experienced the least barriers for entry of the three. As natural gas became more readily available, the distribution companies had minimum up-front investment. Their major problem was selling the idea of natural gas use. With recent developments of plastic and flexible piping, even the notion of economic feasibility to retrofit other energy source users for natural gas is now practical.

One other area of concern is high technology. The past decade has seen an unprecedented outpouring of new natural gas technology. With today's natural gas end-use technology (fuel cells, self-fueling heating and cooling, and vehicles), direct use of natural gas or co-generation with natural gas is the most efficient, least polluting means of providing energy.

## Infrastructure

***Supply.*** Estimates for conventional gas resources in the U.S. are close to a thousand trillion cubic feet, enough to last approximately fifty years at current rates of consumption. Additionally, gas in tight sands, shale, coal seams, etc. are estimated at three thousand trillion cubic feet. Close by, Canada and Mexico offer very large quantities of natural gas resources. New reserves in Indonesia, Qatar and Algeria are ready for immediate production.

***Demand.*** Demand for natural gas is expected to grow from roughly 19 quadrillion Btu in 1988 to 23 Quads in 2010. Most of the demand will be for generation of electricity, gas cooling, and compressed gas for vehicles. With the National Energy Strategy calling for increased reliance on natural gas, the U.S. is likely to increase its annual demand steadily through 2010.

***Ability to deliver.*** U.S. consumers are served by more than 1,150,000 miles of gas pipelines and mains, backed up by storage facilities that can hold 8 trillion cubic feet of gas. This distribution network is adequate for foreseeable needs in most areas, including room for expansion. Additional pipelines are being constructed to satisfy areas experiencing rapid growth.

***Pricing.*** Traditionally, most gas sold at the wellhead was under long-term, price regulated contracts purchased by pipelines, who in turn resold it to local distribution companies and to end-users. The pipelines transported gas as part of a larger package of services (buying the gas, moving it, and storing it). The price to consumers of this pipeline-owned gas reflected the costs of these services and a rate of return on investment. This combination of services used to determine total price to the user was known as "bundled services."

## CONDUCT

### Price Setting

The conventional methodology to establish gas rates is called cost-based rate making.

This approach is geared at ensuring that the industry will recover its cost of service. Under a cost-based rate structure, the commission--either Federal, state, or local--authorizes a rate that is directly derived from the cost of doing business, including an authorized rate of return. Based on calculations of fixed and variable costs, including throughput estimates for pipelines, cost-based rates can be determined. The gas industry recognizes that the cost-based rate structure lacks incentives for encouraging improved performance and efficiency. In fact, the current system encourages padding the rate base by condoning either unnecessary or excessive capital expenditures so that profits are retained.

More recently, the industry has been reviewing incentive pricing mechanisms as an alternative to cost-based rate structures. While actual costs would be a reference point for incentive mechanisms, they would not be the entire basis for determining rates. Rather, other defining issues such as productivity, efficiency and responsiveness would be used to help determine rates. For example, a pipeline rate structure could be based on its actual costs plus its performance in relation to a specific incentive. Under the incentive mechanism, a pipeline would earn more or less than what it would be authorized to receive under the cost--based rate structure. Proponents state that an incentive pricing mechanism would foster lower costs, higher quality, and more rational investment. Opponents question the potential for monopoly abuse.

**Consumer Buying Practices**

The natural gas industry must ensure that their products match customer demand. Indeed, regulatory approved tariffs obligate the industry to provide gas on an uninterruptable basis. Because a significant amount of natural gas is used for heating, the demand is greater in winter. Production and local distribution companies (LDCs) find themselves laboring to meet the peak demand periods during winter months. Often, their efforts are extremely difficult because many pipelines are not presently located where peak demand is found. Because of the disparity in demand, it would not be cost effective for pipelines to handle seasonal demands directly from the wellhead to local distribution companies. This would result in pipelines running at partial capacity for a significant portion of each year. Consequently, underground storage near major gas markets has helped to alleviate a portion of the peak demand problem.

**Government Regulations**

Prior to 1978, all facets of the natural gas industry--wellhead, interstate pipelines, and LDCs--were heavily regulated. The 1970s energy crisis increased the prices of all types of fuels to record levels except for natural gas. Federal price controls artificially underpriced natural gas sold in interstate commerce, which resulted in severe shortages throughout the United States. The government's pricing policy effectively inhibited exploration and production. To encourage exploration, Congress passed the Natural Gas Policy Act (NGPA) of 1978. NGPA was the first major step in redefining the regulation of natural gas. The purpose of NGPA was to allow market prices to determine supply and demand. Specifically, the Act removed or loosened some of the prince controls from the sale of wellhead gas effective in 1985. The Act also established categories of gas according to age, cost of production, location and depth of production wells.

Between 1978 and 1985, the Federal Energy Regulatory Commission (FERC), the agency which has primary responsibility for administering federal natural gas policy, instituted a series of orders that lifted restrictions and provided more access to natural gas markets. Specifically, FERC opened the market for wellhead gas to many sellers and buyers, extended the market for gas beyond traditionally defined geographic boundaries, and promoted open access transportation on the interstate pipelines.

More recently, the Wellhead Decontrol Act of 1989 eliminated all price controls on wellhead natural gas effective January 1, 1993. In addition, the FERC dramatically changed the regulatory environment when it issued Order 636 in May 1992. Order 636 completes the transition from a rigid regulatory control to a market driven system. The central focus of Order 636 is the separation of pipeline transportation from pipeline sales. The Order states that "gas purchasers and gas sellers can structure their relationships as much as possible by private commercial contracts." In short, regulation will no longer dominate business relationships in the natural gas industry. Currently, pipelines buy the natural gas at the wellhead, take title to it, transport it, and resell it to LDCs. Because pipelines bundle natural gas service, the FERC believes that the pipelines have had a competitive advantage over other sellers. Simply stated, a pipeline's operations could favor the transportation of its own natural gas to the detriment of other gas transported by the same pipeline, but owned by another seller. The Order effectively deregulates pipelines' long-term fixed supply contracts with LDCs by ensuring that pipelines provide the same transportation services to all gas suppliers.

**Impact of Deregulation**

With the issuance of Order 636, the FERC removed the last protective shield that surrounded the natural gas industry. While the jury is still out on the Order's total effect, it is expected that there will be an increased demand for gas which will result in increased drilling, production and prices at the wellhead. Increased prices will dramatically improve the financial stability of gas producers.

Order 636's impact on pipelines is mixed. Proponents argue that since pipelines will have no choice but to become more competitive, they will concentrate on improving their transmission efficiency, increasing their storage capacity, and will begin offering complimentary services to their customers. However, greater competition among pipelines may lead to a duplication of facilities and possibly some financial failures. Nevertheless, critics charge that Order 636 is too advantageous to pipelines since it allows them to charge a straight fixed variable (SFV) rate. The SFV rate allows pipelines to recover depreciation, taxes and profit through a demand or reservation charge that is not dependent upon usage. Before Order 636, pipelines were responsible for a portion of their fixed costs. These costs were included in the commodity rate component and could only be recovered if the pipeline sold or transported gas. This forced the pipelines to keep the commodity rate fairly competitive by maximizing the products moving through their systems in order to recover their fixed costs. Opponents maintain that the SFV rate guarantees pipelines their fixed costs without incentivizing them to keep their rates low.

All parties agree that Order 636's greatest impact will be on LDCs. Unbundled service will give LDCs a wider range of supply options to meet their needs rather than having to accept whatever a pipeline offers. Yet, LDCs will assume greater risk for ensuring adequate

supplies and the management of their gas portfolio. LDCs can no longer depend upon interstate pipelines to supply their natural gas needs. LDCs must ensure that they acquire gas on a firm basis for at least their core requirements. Consequently, LDCs will undoubtedly determine that long-term supply contracts are more reliable. An LDC does not want to be searching for supplies when they are tight or when the price is rising. Likewise, sellers will encourage long-term contracts to ensure their own business stability and reduce their administrative costs. However, most LDCs are not equipped to assume the full business responsibilities that pipelines previously provided. Therefore, it is anticipated that large marketers will begin dominating gas markets because of their diverse supplies and regional markets. It is anticipated that their dominance will result in a possible shift back to bundled gas service.

While Order 636 endorses competition through deregulation, it is expected that regulatory scrutiny will switch from the Federal level to the state and local level. The costs, gas rates and purchasing strategy of LDCs will come under greater regulatory oversight from state or local regulatory commissions.

### Capital Investment

The natural gas industry is capital intensive. In order to produce and transport natural gas, the industry requires a greater investment in equipment and facilities than most businesses. On average, the ratio of plant facilities to revenue is 1 to 4 for gas utilities. Since 1980, the investment for new plants and equipment has steadily increased into the billions of dollars. One of the inherent problems of the industry is that it must anticipate the demand for its services years in advance, and then institute construction programs to meet that future demand.

Today, there are large gaps in the natural gas infrastructure. New producing areas in the Rocky Mountains and in the offshore Outer Continental Shelf areas have limited access to major interstate pipelines. Likewise, large population areas in New England and Florida are served by only one pipeline. In short, new production and market areas have emerged which require expansion of the nation's interstate pipeline system.

### Research and Development

Because research and development (R&D) requires major investments, only a limited number of large wellhead producers have the required capital required for investment. Since Federal and state governments provide minimal R&D funding, the majority of R&D Is funded by the gas industry itself. The Gas Research Institute (GRI), the industry's R&D organization, coordinates all industry research activities. Most R&D is concentrated on environmental improvements rather than production and transportation improvements.

Before the natural gas industry can make significant advancements in R&D, it must design a long-term funding mechanism for GRI. The traditional methodology for funding GRI broke down in 1992. To adequately fund the GRI, the industry must face potential cost shifts among regions, anticipate the impact of Order 636, and allocate long-term risk among pipelines.

## PERFORMANCE

### Trends and Future Prospects

The natural gas industry is undergoing significant competitive realignment as a result of broad regulatory reforms and severe financial pressures on gas producers during a period of expanding demand and reduced production capacity. Three key factors will affect the future growth and structure of the natural gas industry:

***Timing and extent of gas supply development.*** Ongoing discoveries in the Gulf of Mexico, Mobile Bay, and British Columbia suggest that there Is an abundant resource base in North America. Continued low wellhead prices for natural gas have helped to keep demand high at the same time that investors have been discouraged from new exploration and development activity. The net effect is reduced U.S. gas production capacity. This fact, when considered against a backdrop of rising demand, has the potential to lead to peak-period supply constraints, short-lived price spikes and heightened price volatility. It remains to be seen if market factors will lead to increased exploration, production and resulting supply increases. The demand seems certain.

***Continuing industry restructuring.*** Changing federal regulations will reduces the merchant function of the pipeline sector of the industry,shifting more of the risk for supply acquisition and portfolio management to distribution companies. The likely outcomes of regulatory changes are increased interest in natural gas storage, gas aggregation and balancing services and longer-term supply contracts. Distribution companies are likely to feel increasing political and regulatory scrutiny over their rates and costs as they balance new integrated resource planning procedures with the demands by large users and marketers.

***New markets.*** Natural gas has a strong, competitive advantage for new markets since its costs and environmental impacts are relatively low. Power generation is the most significant expansion market for the future. Lesser markets for expansion include commercial air conditioning, natural gas vehicles and increased exports to Mexico. Key to capturing these markets will be assurances by the industry that short and long-term supply can guaranteed.

### Profitability

Total revenues from sales of natural gas have steadily declined since the mid-1980s, with residential and commercial sales showing slight increases, and industrial and resale markets showing strong declines. Over the 20 year period (1971-1991), residential customers grew by 5.4%, commercial customers grew by 6.1%, and industrial customers decreased by 27%. As a representative example of the natural gas industry since 1980, the investor-owned gas utility industry has kept long-term debt at constant levels, shown slight growth in common equity value and suffered a significant erosion in preferred stock value.

### Production

Prior to 1975, the U.S. produced and consumed about one-half of the world gas supply. During the period 1970-1988, gas consumption tripled in all major industrial nations of the world except in the U.S., where it fell by 15.4% during the same period.

More recently, demand for natural gas in the U.S. has made a significant turnaround.

Consumption rates should also increase. The U.S. has produced an average of 25% of the world's gas in the past. That share is likely to increase contingent upon increased exploration and development by U.S. firms. Replacement of production by additions to reserves was 84.9% in 1991, as compared to a prior 10-year average of 93%. There were only 860 active gas drilling rigs in 1991 and 659 in 1992. These are the lowest numbers in recent history, reflecting decreased exploration and development. Reserve margins are decreasing as producers use a just-in-time manufacturing approach to meet demands. Falling production capacity of existing wells and difficulty of producing in some of the new fields like the deep water wells in the Gulf of Mexico are making it harder to meet new demands.

**Export Competitiveness**

The U.S. uses more gas than it produces. Imports reached a record level of 1.6 trillion cubic feet in 1991, representing about 7% of the total gas consumed in the U.S. Estimates are for imports of over 2 trillion cubic feet in 1993, accounting for 12% of domestic consumption. Imports come primarily from Canada. There is a small export market from the U.S. for liquified natural gas from two active terminals, but export levels have remained steady over the last twenty years. There is also an export market for natural gas to Mexico that is expected to grow until Mexico can build sufficient infrastructure to meet internal demands. U.S. demand is projected to increase by 5% between 1992 and 1997, but production is expected to grow by less than 1%. Imports will have to make up the difference.

**Employment and Wages**

The natural gas industry employed just over 2 million workers in 1975 and employs just over 2 million today. During the period 1975 to 1991 average wages rose from $13,570 to $39,881 per year.

**ISSUES**

**How will electric utilities meet increased demand for electricity, reduce environmental pollution and, at the same time, keep capital and operating costs under control?**

Natural gas can be the choice fuel for helping electric utilities cope with these seemingly conflicting challenges. Relatively small quantities of gas co-fired with coal can greatly reduce air pollution. Gas-fired equipment can be used to prolong the life of existing electricity generating facilities. Combined cycle technology, which makes use of waste heat to generate additional electricity, is an efficient and cost-effective procedure for constructing new electric capacity. This technology also has the advantage of relatively low capital and operating costs. It allows for flexibility through modular construction and can be offered and installed in a relatively short period of time.

**Environmental concerns and the likelihood of even greater dependence on foreign sources of oil have focused attention on the potential of natural gas to meet a greater proportion of the Nation's energy requirements. Will the natural gas transmission capacity be sufficient to meet the Nation's growing dependence on natural gas?**

At present the Nation's pipeline capacity is generally perceived to be adequate to serve

the peak-day requirements of its core customers in most regions of the country. Additionally, it satisfies non-core customers without major concern for unexpected interruptions. Certain areas of the country--the West, Northeast and South Atlantic--experience very high capacity utilization. This is where capacity constraints could become binding without expanding the existing pipeline system.

Planned and proposed capacity additions will play an important role in meeting the projected increased consumption. If all these projects are built, capacity will increase roughly 13%. This is approximately what the National Energy Strategy predicts as the increase in demand for natural gas by the year 2010. However, the economic basis for some of the planned expansions may change as federally issued regulatory initiatives begin to take effect. These regulations would allocate the cost of the expansion projects more directly to the customers benefiting from the projects, and they require pipeline companies to assume substantially more risk for uncommitted new projects.

Therefore, some expansion projects may not materialize in the current form and others may be downsized or abandoned altogether. The Federal Energy Regulatory Commission (FERC) must closely monitor the reassignment of capacity that is mandated in Federal Order 636. Also the FERC must evaluate the implementation of regulations regarding the construction of new pipelines to ensure that the transmission capacity is adequate to meet the Nation's increasing demand.

**Will the natural gas industry be able to meet expected increasing demands into the 21st century?**

While deregulation, policy emphasis on increased use of natural gas and environmental advantage of natural gas have the potential to stimulate the industry and provide the necessary synergism that market forces require before investment in exploration and production capacity are possible, it remains to be seen whether performance will match expectations.

Even though the natural gas industry is optimistic, there is considerable ground to cover before domestic production can hope to meet projected increased demand. Since the industry has been the most regulated in the energy sector, it is difficult to predict the effects of deregulation. Also, if prices at the wellhead rise as predicted, investors may be encouraged to invest in needed exploration and production. However, these same price increases may curb overall demands.

Environmental concerns about energy are only beginning to be defined. While natural gas is certainly the lesser of the evils in affordable energy, the potential for it to be further restricted is a distinct possibility.
If all factors work together and market forces cause a relative shift to natural gas as the energy source of the future, the United States, in conjunction with Canada and Mexico, can meet the future demands in the U.S.

**Will the natural gas industry be able to clean up environmentally hazardous dismantled plants?**

Manufactured gas sites that existed before the introduction of modern natural gas production techniques are environmental hazards. Until pipeline gas was introduced just before World War II, manufactured gas was produced in gas plants throughout the United States, with the heaviest concentration in the industrial cities of the North and East.

The coke oven process used left a number of coal tar residues, including sulfur and cyanide compounds, aromatic hydrocarbons or light oils, naphthalene and ammonia. Unsalable byproducts were usually disposed of on site. When the manufacturing gas plants were retired from service, the plants were dismantled and buried along with the residual toxins on the site. These sites have not been cleaned up and contain an environmental time bomb that will require massive amounts of money to neutralize the environmental hazards.

## ENERGY SECTOR: PETROLEUM

### STRUCTURE

#### History

The development of U.S. crude oil and refinery industries in the Northeast in the mid-1850s resulted from discoveries of natural deposits found seeping into the earth's surface. It is believed that the first use of oil was by native Americans for medicinal purposes. Other early Americans used the first crude oil products for lighting sources as an alternative to whale oil. New technologies and innovative recovery techniques allowed crude oil production to grow with demand throughout the industrial revolution period.

The first U.S. refinery began operations in the early 1860s. Although some greases and lubricants were produced, the early refinery industry concentrated efforts on producing kerosene for the illuminant market. Transportation infrastructure emerged during this same decade in the form of the first railroad tank car in 1865 and the first oil pipeline in 1869.

Perhaps the greatest catalyst for the infant crude oil and refinery industries was the invention and subsequent mass production of the automobile. Gasoline, which up to this point had been a waste product in the distillation of crude oil, quickly replaced kerosene as the refined product most in demand. New crude oil discoveries, coupled with new technologies such a cracking units, allow the industries to increase production in response to increasing consumer demand.

In the first half of the 20th century, the petroleum industry served the country well, particularly in the production of specialized refined products to meet the war needs--aviation fuels, lubricants and medicinal oils. Overall consumption of petroleum products more than doubled between 1940 and 1950 as Americans took to the highways in their new family automobiles. Consumption was so high that in 1946, petroleum products supplied more of America's energy requirements than coal.

Today, America's energy needs are increasingly dependent upon foreign suppliers. Conservation initiatives enjoyed brief success following the import interruptions of 1973 and 1978-79; however, overall crude oil demand continued to grow. The Organization of Arab Petroleum Exporting Countries (OAPEC) now represents the majority of known world crude oil reserves. Foreign oil will remain a significant element of America's energy well into the 21st century.

#### Industry Definitions

America's crude oil industry (SIC # 1311) is defined as establishments engaged in operating oil properties. The industry includes exploration drilling, completing and equipping ells, operation of separators, emulsion breakers, desilting equipment, extraction of oil from shale oil, and oil marketable up to the point of shipment from the producing property.

The petroleum refining industry (SIC # 2911) is made up of establishments primarily engaged in producing

gasoline, kerosene, distillate fuel oils, residual fuel oils, redistillation of unfinished petroleum derivatives, cracking, or other processes.

## Concentration Ratios

Both the crude oil and the petroleum refining industries fit the U.S. Department of Justice classification of "unconcentrated;" i.e., with a four-firm concentration ratio of less than 50 percent of the industry. As illustrated in Table 1, the domestic oil producing market is unconcentrated, with the top four firms in 1991 (BP America, Arco, Exxon and Texaco) representing only about 27 percent of the industry. The four-firm concentration ratio has declined in each of the previous three years from a 1988 high of 287 percent. The period between 1989 and 1990 showed the largest four-firm concentration decline of one percentage point. Industry experts speculated that one of the several reasons for the four-firm concentration ratio decline was due to mergers among the smaller industry firms.

Table 1. Net Crude Production

Net Crude Oil Production
(Concentration Ratios) Percent of U.S.Total

| Year | 4-Firm | 8-Firm | 15-Firm | 20-Firm |
|---|---|---|---|---|
| 1991 | 27.2 | 44.5 | 55.6 | 58.9 |
| 1990 | 27.5 | 45.3 | 56.4 | 59.5 |
| 1989 | 28.5 | 46.4 | 57.5 | 60.4 |
| 1985 | 26.1 | 43.5 | 55.2 | 58.4 |
| 1980 | 25.3 | 40.8 | 56.1 | 60.5 |
| 1975 | 25.0 | 41.2 | 57.0 | 61.2 |

Source:DOE/EIA-0215(91)

Petroleum refining industry concentration ratios are similar to those of the oil producing firms. The top four domestic refining firms (Chevron, Exxon, Shell and Amoco) are unconcentrated, representing only 30 percent of the refining market in 1991. The top eight firms represented nearly 50 percent of the market.

As illustrated in Table 2, both the four and eight firm concentration ratios have declined over the past six years due to smaller firms merging and increasing their size of the market. Foreign refining interests have also influenced the concentration ratios and trends.

## Buyers

Overall, the transportation industry is the number one user of oil products. In 1990, nearly 70 percent of all oil products were used by the

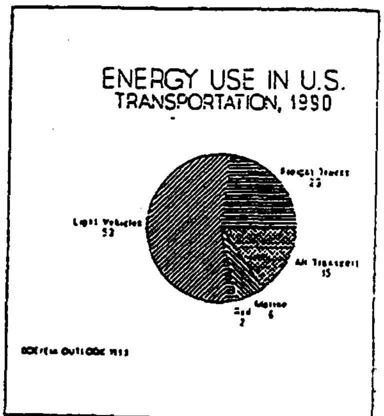



Figure 1. Percent Oil Yield

Table 2. Concentration Ratios

Concentration In Refining
Capacity (Percent of Total Capacity)

| YEAR | 4-FIRM | 8-FIRM | 15-FIRM | 20-FIRM |
|---|---|---|---|---|
| 1991 | 30.3 | 45.[illegible] | 59.3 | 78.5 |
| 1990 | 31.0 | 49.5 | 69.6 | 78.6 |
| 1989 | 31.6 | 50.0 | 62.9 | 77.9 |
| 1985 | 34.4 | 54.4 | 73.0 | 80.3 |
| 1980 | 29.0 | 49.0 | 67.0 | 74.5 |
| 1975 | 29.9 | 53.5 | 74.1 | 81.3 |

Source: DOE/EIA 0215(91)

transportation (motor fuel, 56 percent; aviation, 11 percent) sector. Just 18 percent was used for heating or cooking. The small balance of oil products (approximately 11 percent) was used in electrical generation. Figure 1 illustrates the oil usage in U.S. Transportation in 1990.

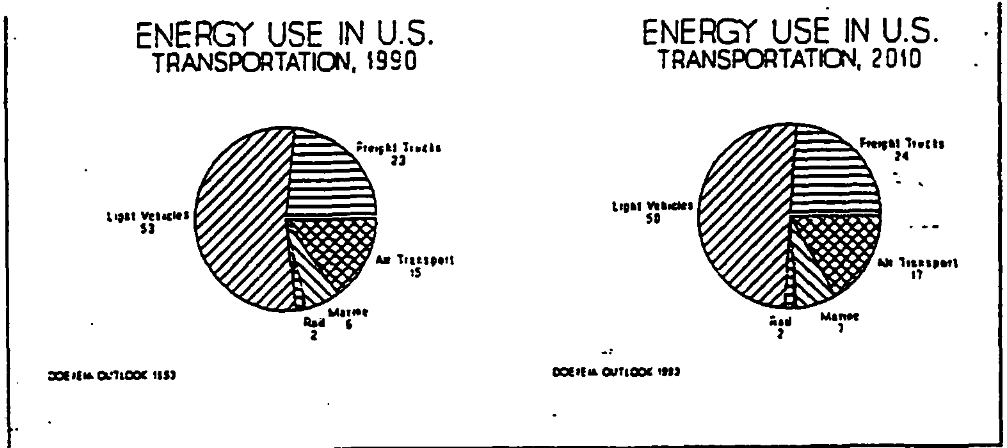



Figure 2. Energy Use Comparison

The transportation sector depends almost completely on petroleum as an energy source. Petroleum consumption by the transportation sector has increased over the past ten years, while other end-use sectors have switched from petroleum to natural gas and electricity. Figure 2 compares petroleum use in U.S. transportation in 1990, with government projections for the year 2010.

Barriers to Entry

The exploration, development and production expenditures associated with getting into the oil business is a significant barrier-to-entry. Prior to 1975, the largest U.S. expenditures were in the exploration sector. Exploration includes drilling and equipping wells, acquiring undeveloped acreage, land department leasing and scouting, geological and geophysical costs, lease rentals, test hole contributions, direct overhead, and general administrative costs. In 1990, the largest expenditures include direct operating expenditures, taxes and general administrative costs.

The cost of getting into the refining industry is even more costly than the oil industry. The last major U.S. refinery was built in 1980 in Freeport, Texas, costing over $500 million. It operated at a loss for just one month and has never resumed operations. Refining capacity has increased as a result of existing refineries expanding and reconfiguring. Recent expansion of refinery capacity is the result of new EPA specifications. Lower yields and lower product imports combined to increase U.S. petroleum refinery utilization. Practically all of the output of U.S. petroleum refineries goes to the domestic market. The U.S. market is the largest in the world.

Labor

The U.S. crude oil and petroleum refining employees have enjoyed some of the highest hourly earnings in the country. In 1991, the average U.S. petroleum refining employee earned $18.11 per hour, while the crude petroleum worker earned an average of $16.60 per hour. In

comparison, the coal mining employee earned $14.18 per hour, while the average U.S. manufacturing job paid about $11.18 per hour. Crude oil and refining employees are routinely high school graduates and must be proficient in operating sophisticated drilling and refining equipment. The trends are decreasing away from unionized labor.

Infrastructure

The petroleum industry infrastructure can be divided into three categories: crude oil availability, refining capacity and the transportation system.

Crude Oil Reserves are estimated volumes of crude oil anticipated to be commercially recoverable from known accumulations from a given data and under existing economic conditions, by established operating practices, and under current government regulations. "Provided Reserves" must have facilities that are operational at the time and have a reasonable certainty of being recoverable under current economic conditions.

In 1991, both falling crude oil prices and a 20-year low level of exploratory wells and active drilling rigs combined to result in a five percent decline in the level of crude oil reserves in relation to the 1990 level. Oil reserve ownerships remained more concentrated than the rest of the industry, with the top four-firm ratio representing nearly 32 percent of all U.S. crude oil reserves. The reserves-to-production ratio for Alaskan oil is higher than the reserves-to-production ratio for oil located elsewhere in the U.S.

The principal reasons for the 1991 decline in crude oil proven reserves was due to the following factors:

- High production in early 1991 following the surge production of 1990 in response to the Gulf War.

- The continued U.S. recession in 1991.

- Increasing environmental costs and restrictions.

In addition to proved crude oil reserves, non-producing reservoirs exceeded two billion barrels in the period ending 1991. Improved recovery techniques from known reservoirs holds significant promise for increased recovery volumes.

U.S. Refining Capacity continued its six-year decline in 1991. Total refinery capacity represents the total input processed through crude oil distillation units. The top eight refinery firms lost the most market share. Between 1970 and 1991, the concentration ratio of the top eight firms fell from 61 to 50.9 percent. With the exception of early in 1991, most refiners decreased their capacity due to the continued sluggish economy.

The Transportation System uses ocean-going tankers and pipelines as the most common means of transporting crude oil to refineries. Pipelines and trucks represent the most significant means of moving petroleum products. In 1990, pipelines transported over 53 percent of all crude oil in the U.S., while water carriers represented 42.3 percent, and motor carriers just 2.8 percent. Pipeline transportation trends have increased over the past 12

years, while water carriers have showed a slow, but steady increase. Total U.S. pipeline construction has increased since 1947 to over 1,206,000 miles. The U.S. tanker fleet has declined to an all-time low of 247 ships in 1989. The U.S. has only added eight ocean-going vessels to its fleet since 1985.

## CONDUCT

### Prices

Overall, the U.S. oil industry has, and will continue to be a healthy worldwide leader, and is an essential part of the domestic economy. The financial well being of the industry is so closely tied to the price of oil that it tends to suffer when crude oil prices are low.

During the past 30 years, the price of imported crude oil has varied greatly. As shown in Figure 3, real oil prices fell gradually to about $10/bbl in the early 1970s before rising sharply in two steps: first, tripling in 1974 following the Arab oil embargo, and then nearly doubling following the Iranian revolution and the outbreak of the Iran-Iraq war. Since then, prices have stabilized between $16 and $22/bbl, except for a brief price spike in the fall of 1990 following the Iraqi invasion of Kuwait.

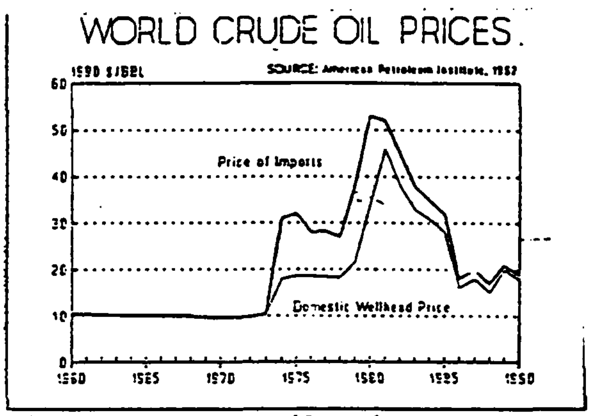



Figure 3. Crude Oil Prices, 1960-1991

On the other hand, domestic price controls have remained well below the import levels throughout the 1970s and 1980s. With decontrol of prices this gap narrowed sharply in the early 1980s, but moved toward a falling target with the decline in world prices.

The decline of oil prices spelled trouble for U.S. oil companies. The Southwest lost its affluent Sunbelt aura and became one of the most depressed regions of the country. Smaller players folded and larger companies experienced a dramatic period of restructuring that included consolidations, takeovers and financial maneuvering. In 1986, the woes of the industry intensified as the decline in oil prices accelerated. Congress talked of instituting an import fee to discourage use of foreign oil and help prop up domestic prices. By the 1990s, the pendulum was swinging back toward the oil industry. Despite a price surge during the Iraqi invasion, prices stabilized at the late 1980s price level.

### Government Regulatory Policy

The Department of Energy (DOE) and Energy Information Administration (EIA) have conducted several studies of the impact of energy policy on oil production, prices and uses. In general, each reviewed the effects of guarantees, grants, tax credits and acquisition subsidies.

The result of these activities suggest that many government programs can have offsetting

effects, even within market and programmatic areas. If conservation of programs are removed but energy prices are also forecasted to increase, then the economic conservation (in response to higher prices) replaces the mandated conservation to some degree. The finding of greatest interest was that the wide array of government actions taken together, while offsetting another, did not have large quantitative net impacts.

In 1990, The Congressional Budget Office conducted a study to determine the environmental effects of energy production and consumption. It concluded that Federal impacts favoring fossil fuel use were small relative to those which favored non-fossil sources or taxed use of fossil fuels. This underscores an important point that measurable tax, expenditure and credit programs tend to pale in relation to the size of the energy sectors they impact.

Labor

Soon after the development of the oil industry in the late 19th century, oil field workers started organizing in Pennsylvania, the main producing area. In 1889, the various small unions were consolidated into the AFL Chartered International Brotherhood of Oil and Gas Well Workers.

The birth of the oil industry in Texas brought a new round of organizing and the unions reached a high point of power during World War I. Yet, after the war, the industry once again moved to enforce its open shop policy and the unions waned. It took the National Industrial Recovery Act of 1933 to revive union activity. A national organization called the Oil Workers International Union (OWIU) achieved a number of successes and went over to CIO.

During the 1940s and early 1950s, the OWIU suffered from persistent internal political battles and rivalries with other industry unions. Problems continued even after a 1955 merger with the United Gas, Coke and Chemical Workers of America. The combined union--renamed the Oil, Chemical and Atomic Workers (OCAW)--kept a strong foothold in the industry but did not achieve much additional growth.

The OCAW faced obstacles in the increasingly automated refining sector of the industry and barely managed to keep wages rising and to hold into its members. The problem got worse with the industry slump of the 1980s. Management began demanding contract concessions and, in the mid-1980s, the unemployment rate among oil workers was well above ten percent. Yet, by 1990, the situation had improved enough so that the OCAW was able to preserve its industry-wide contract and win good improvements in wage rates and health insurance.

Government Regulations

Oil import dependency has been a major energy policy concern since the 1973-74 Arab oil embargo. Corporate Average Fuel Economy (CAFE) standards on automobiles passed as part of the 1975 Energy Policy Conservation Act and designed to reduce the level of imports, has also increased the ownership costs of automobiles by an average of $370 million per year.

Air pollution from automobiles is another area of heavy regulation. In 1970, Congress passed legislation to regulate fuel additives such as lead. It also included emission control requirements to reduce the level of hydrocarbon, carbon dioxide and nitrous oxide gases. The Clean Air Act Amendments of 1990 contain a number of requirements and limitations that affect fuel use for transportation. Recent estimates of the cost of compliance indicate additives used to meet required oxygenated levels begun in 1992 will increase gas prices by three to five cents per gallon, at a cost of $540 million annually. Diesel fuel desulfurization will go into effect in 1993, raising the price by four cents per gallon. In 1996, military jet fuel standards will change to kerosene-based jet fuel.

At least some portion of both supply decline and the sharp decline in drilling activity witnessed in the 1970s and early 1980s was attributable not to resource scarcity but, rather, to government policies. First, Federal government price controls and taxation kept domestic wellhead prices well below the cost of oil in the international market, depressing the incentive to invest in domestic reserve additions. Second, a pattern of multi-tiered price controls and taxation served to distort the drilling that did occur toward new fields which contributed little to overall reserve additions. By 1990, these regulatory effects were replaced with constraints on land access, further restricting supply investments to the on-shore lower 48 states.

## Capital Investments

Higher oil prices provided increased profits for distribution as dividends to stockholders. However, oil companies tend to invest these increased revenues much more heavily in capital expenditures than in dividends. Figure 4 shows expenditure trends over the past 20 years. Capital investment dramatically increased in the late 1970s and early 1980s, driven by the $30-50/bbl crude oil prices. In the mid-1980s, capitalization sharply decreased as profits and oil prices declined.

Capital expenditures for projects in the U.S. by U.S.-based companies were projected at $32.5 billion for 1992, down six percent from $34.6 billion in 1991. The big cutbacks will be in exploration and production, where spending was expected to be down by 11.4 percent in 1992. Refining outlays, the largest component, were slated to rise 8.3 percent.

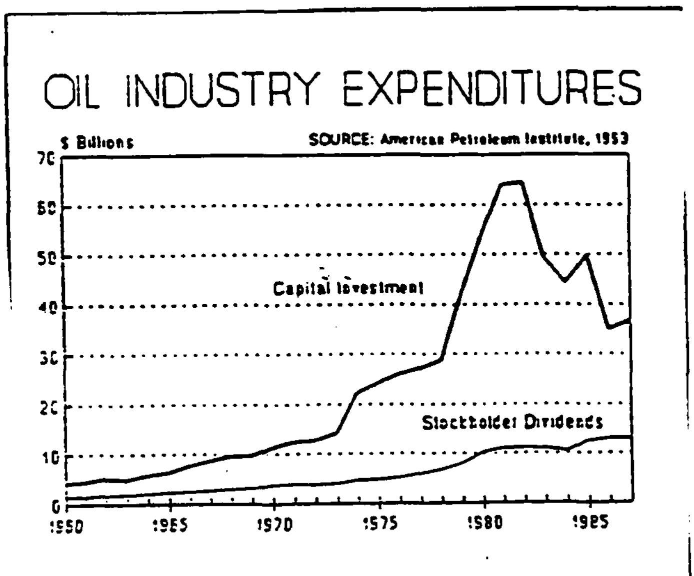


Figure 4. Investment Trends

## R&D

In the current weak pricing environment for oil and natural gas, there is intense pressure to lower the costs of finding and lifting these natural gas resources. The service and drilling sectors have emphasized development of new technology and are trying keep production both feasible and profitable. In particular, major strides have been made in the exploration and

development of off-shore sites where most of the world's remaining oil reserves are believed to be located. Among the most promising technologies are:

- o 3-D Seismic surveys
- o Offshore tension-leg platform deep water rigs
- o Horizontal and directional drilling
- o Enhanced oil recovery techniques

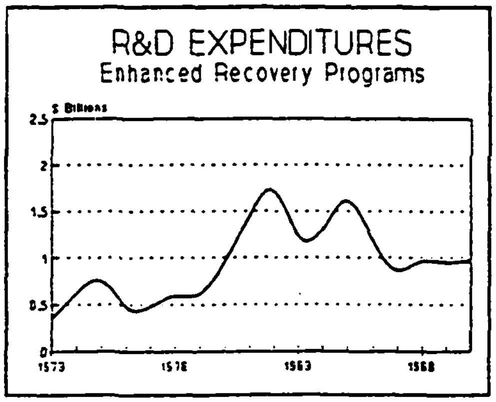



Figure 5. Enhanced Recovery R&D

Figure 5 shows R&D investment on the latter technology follows a trend similar to that exhibited by prices over the past 20 years. R&D increased moderately while prices were low and peaked in the early 1980s when prices were high. Yet, industry's recognition of the need to lower costs of recovery are evident in the sustained higher R&D, while prices weakened in the late 1980s.

Federally funded R&D efforts are relatively small. The FY 1992 R&D budget for oil-related programs amounted to $51.3 million, mostly aimed at research on enhanced oil recovery. According to the DOE National Energy Strategy, the proposed near-term R&D measures would result in additional oil production that would peak at 1.4 million barrels per day by 2005. They would add total oil reserves of five billion barrels (at $20/bbl) to more than 25 billion barrels (at $50/bbl). The R&D program would, if fully successful, increase the amount of economically recoverable reserves by between 20 and 65 billion barrels depending on the price.

## PERFORMANCE

### Revenue

A trend demonstrated by the petroleum industry over the years is that revenues generated through sales are directly dependent on the price of crude oil. The revenues of the 20 leading petroleum companies in the U.S,. as surveyed by the American Petroleum Institute (API),

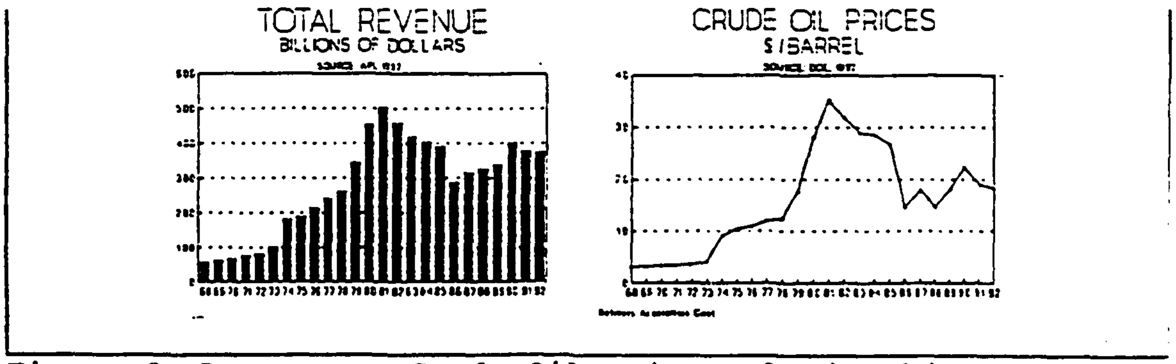



Figure 6. Revenue to Crude Oil Price Relationship

have risen and fallen in tune with crude oil prices. Figure 6 illustrates the relationship between the price of crude oil and total revenues. The surge of crude oil prices in 1973-74 and in 1979-81 are especially evident.

Annual revenues peaked in 1981 when the price of oil peaked at over $35 per barrel. Revenues fell in 1986 in the wake of the price collapse of crude oil. This point highlights the interdependence and the price of crude oil.

The total revenues for petroleum companies as of the third quarter of 1992 indicate about a 1 percent decrease thus far from 1991 revenues of $379 billion. This is 5.8 percent below the $402 billion reported in 1990, but 11.7 percent above the $339 billion reported in 1989. These changes in aggregate revenue primarily reflect the changes in worldwide refiners acquisition cost of crude oil: prices averaged $17.97/barrel in 1989, $22.22/barrel in 1990, $19.05/barrel in 1991 and $18.20/barrel in the third quarter of 1992. The sharp increase in crude oil prices in 1990 was due to the Iraqi invasion of Kuwait in August 1990. The corresponding uncertainty in world crude oil supply persisted until early 1991 and then dropped after the liberation of Kuwait.

Net Income

The 1992 net income for the API sample of petroleum companies as of the third quarter of 1992 indicates a 25 percent decrease from 1991 levels. This is a 21 percent decrease from 1990 and 11.4 percent below 1989 levels of earning. The bright spot in the third quarter 1992 earnings over third quarter 1991 was a 10 percent increase in overall earnings for the period, due primarily to the increase in crude oil prices during the second half of 1992. However, downstream earnings were lower, as refined products failed to keep pace with the rising crude oil prices.

As a result of modest increases in refined products demand and rising crude oil prices, margins realized on refined products fell between the third quarters of 1991 and 1992. As a consequence, income from the major and independent refiners/marketing operations dropped.

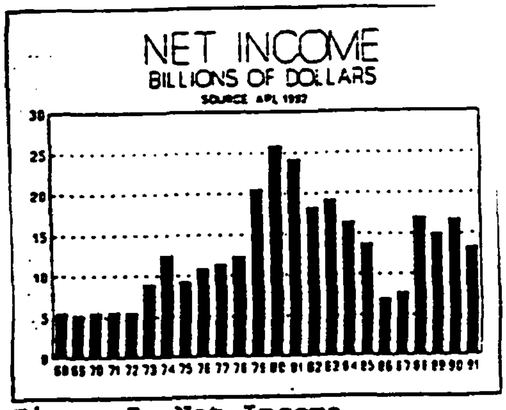


Figure 7. Net Income

Profitability

Return on Stockholders Equity is the ratio of net taxes to the stockholders equity and measures the rate of return on the stockholders investment. The net income decline in 1991 reflects lower profitability, as indicated in Figure 7.

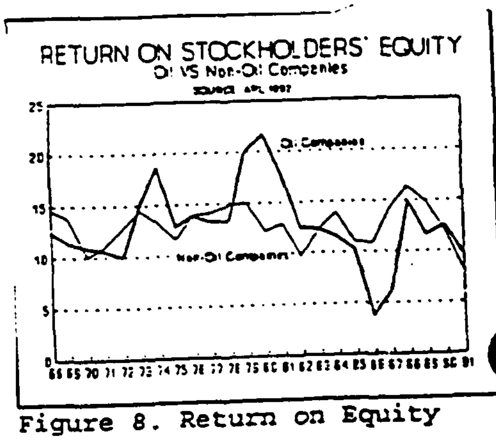


Figure 8. Return on Equity

As Figure 8 shows, return on net worth fell from 12.6 percent in 1990 to 9.7 percent in 1991, the third lowest rate since 1968. The other two years were in 1986-87.

The figure also indicates that the petroleum industry has seen average profitability over the long haul, as they have averaged a 12.5 percent return since 1968 and the non-petroleum industry at 13.1 percent return. Forecasts by the Department of Energy reveal that the 1992 return on net worth will be in the 11 percent range.

Liquidity and Capital Resources:
Working Capital is defined as the difference between current assets and current liabilities. The amount of working capital at a particular time represents the excess of cash, or near term claim on those assets. As indicated in Figure 9, the working capital of API sample of petroleum companies has declined over the past five years, and was negative in 1991.

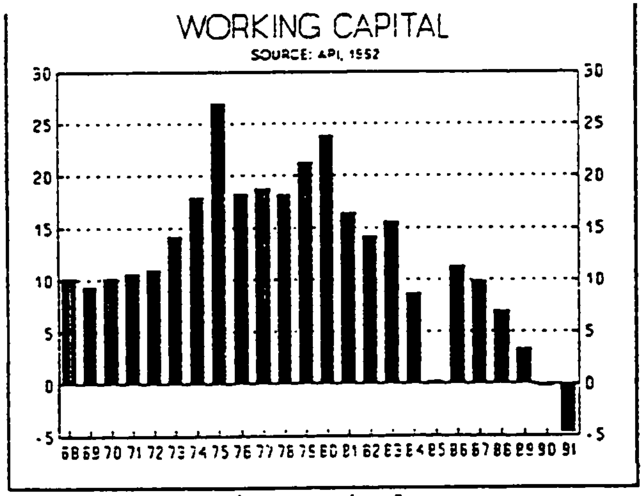



Figure 9. Working Capital

The current ratio is the most common measure of short-term liquidity, or the ability of a company to meet its current obligations. The current ratio is the ratio of current assets to current liabilities. The business standard is a ratio of 2.5 assets to 1.0 liabilities. The petroleum industry has gone from a high of 1.81 in 1968 to 0.94 in 1991.

The Debt Ratio is the ratio of total debt to total assets and measures the total amount of funds provided by creditors. The ratio of debt to equity is simply a transformation of debt to asset ratio. Creditors prefer moderate debt ratios in the range of 30-40 percent because the lower the ratio, the less of a possibility that the creditors will suffer losses in the event of a liquidation. In contrast, the industry prefers a higher debt ratio because it can magnify earnings and reduce capital requirements.

Figure 10 shows that the debt ratio remains high, thought it is slightly below the peak reached in 1985. The sharp increases in the debt ratio in 1984 is attributed to the debt-funded acquisitions of oil company stock. Historically, the debt ratios of petroleum and non-petroleum companies have generally been the same. The oil companies jumped to the 60 percent range in the early 1980s, followed by non-oil companies later in the decade.

Mergers and Consolidations

Over the past 12 years, there has been considerable turmoil in the petroleum industry, especially with the high number of mergers, consolidations and companies going out of business. The number of top companies listed in the Oil and Gas Journal (OGJ) has dwindled from the peak in 1981 of "Top 400" to the "Top 300" of today. There were 324 refineries in operation in 198. Within a four-year span, 101 companies folded as

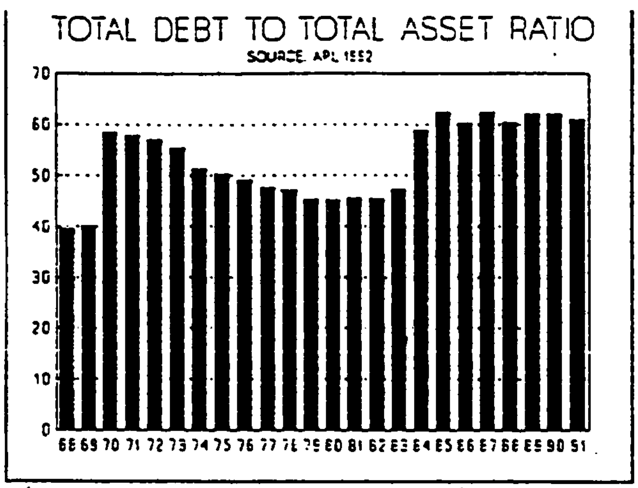



Figure 10. Debt to Asset Ratio

a result of mergers, consolidations or closures. Today, there are 199 refineries in the U.S., of which only 183 are currently operating.

Major movement in the consolidation of refineries began in 1981 when CONOCO merged with the Dupont Chemical Company. In 1982, the Marathon Oil Company merged with U.S. Steel Corporation and Occidental Petroleum Company to purchase Cities Services. In 1984, Chevron purchased Gulf Oil, Texaco purchased Getty Oil Company, and Mobil purchased Superior Oil. In 1987, British Petroleum of America gained control of the remaining 45 percent minority interest in SOHIO. Over the past several years, the industry has stabilized, with minimal realignments.

POLICY ISSUES AND TRENDS

Foreign oil dependence: The decreasing U.S. proved reserves and the corresponding increase on reliance of imported oil is resulting in a greater dependence on foreign oil to meet basic U.S. needs. The biggest impact would be on our transportation sector, which relies on petroleum products almost entirely to meet its needs.

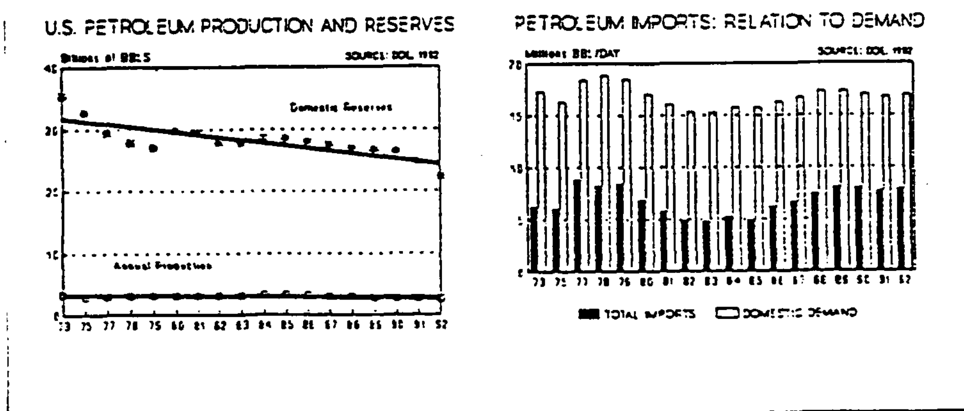



Figure 11. Production and Reserves vs Demand

As indicated in the left chart of Figure 11, U.S. demand for refined products has ranged from a high of 18.8 million bbl/day in 1978 to a low of 15.3 million bbl/day in 1983. However, the amount of proven reserves in the U.S. have declined to an all time low of 21 billion barrels, down from over 36 billion barrels in 1973. At present levels of production and consumption, this is only an eight-year supply.

Refinery capacity: A similar and related problem is the decrease in refinery operations and capacity. Since 1981, the U.S. has decreased from 394 refineries producing almost 19 million bbl/day to 199 refineries producing 15.7 million bbl/day. The end result is that the U.S. is now importing more refined products than ever before. Given the above situation, the U.S. refinery industry could be in more even more reductions.

Increasing globalization: The increasing globalization of the petroleum industry is the fundamental trend that is shaping the international oil and gas industry. The clearest reflection of the industry's globalization is the continued increase in exploration and development expenditure outside the U.S., which rose for the fifth straight year. In 1991, this totaled $31.4 billion, up 27 percent from 1990. Conversely, U.S. explorations and

development dropped by 4 percent to 17.7 billion.

In 1992 and the coming years, U.S. exploration and development spending levels are expected to decline at a faster rate as companies follow through on their overseas expenditures, while continuing to shift their U.S. focus to areas that have the competitive advantages and will establish infrastructure that can help them reduce costs. At the same time, many smaller and larger companies are divesting non-strategic properties in the U.S. The trend of reduced exploration and development exacerbates the issue of declining proved reserves in the U.S.

Innovative financing: As the debt ratios of the petroleum industry have risen from 38 percent in the 1960s to over 61 percent in the 1990s, many companies have turned to innovative approaches for raising capital to finance their operations. Bank loans still serve as a major source of capital, but the petroleum companies are refinancing current loans, extending amortization rates of their loans, refinancing into revolving credit lines, and increasing use of the international syndicated loan markets. These are specialized lenders who understand the turbulence of the oil markets and are willing to provide capital.

Other methods being used include issuing bonds and other public debt interests to raise capital. Some companies like Maxes Energy (an independent and 27th largest petroleum company in the U.S.) still aim at a debt ratio of 30 percent, with 70 percent equity. It allows them to achieve an investment grade rating, which in turn reduces the cost to the company issuing public debt, and improves its ability to tap into the long-term public debt market.

Reduced Proved Reserves: The trend continues that indicates regional reduction in proved reserves in the U.S. Canada, Africa, Australia/Asia, Western Europe, and Commonwealth of Independent States (CIS). Only in Latin America and the Middle East are the proved reserves growing annually. Without the addition of proved reserves in those regions that show a trend for reduced reserves, an increasing reliance on Latin America and the Middle East will continue.

## ENERGY SECTOR: RENEWABLE SOURCES

All energy sources are either renewable or nonrenewable. Sun, wind and water are natural, renewable resources that can supply power over and over again. Renewable energy resources are converted into usable energy through a variety of known technologies: photovoltaics, wind turbines, biomass, waste combustion and hydropower. As the following comparison between renewable and conventional domestic resources used to generate electricity indicates, the current domestic resource potential of renewable energy resources is 93.3 percent of estimated total current domestic energy resources.

**Table 1**
**Domestic Energy Resources: Conventional and Renewable**
**(billion barrels of oil equivalent)**

| Total Domestic | Current Resources | Accessible Resources |
|---|---|---|
| Renewable | 613,800 | 105,975 |
| Conventional | 43,795 | 9,127 |
| Total | 657,596 | 115,103 |

*Accessible resources are those that can be located, mined or extracted by technology which is currently available or which is expected to be available in the very near future (3 to 5 years).
*Source*: U.S. Export Council for Renewable Energy, Renewable Energy for the World, September 1990.

Renewable energy is abundant, accessible and environmentally safe. However, it may be surprising to learn that at present, renewables supply just 8 percent of total U.S. energy demand--13 percent of the nation's electrical consumption. Most of the energy (86 percent) comes from hydropower and the burning of biomass (wood, wood wastes, agricultural wastes and municipal wastes).

What is going on here? If renewable energy is so abundant, accessible and clean, why doesn't it supply more of the U.S. total energy demand? This is one of the primary issues considered in this examination of the following renewables: biomass conversion, ethanol and methanol, geothermal, solar and wind sources.

### HISTORY

The history of renewable energy goes back to ancient times when solar energy was used to heat homes and wood was used to cook food. President Truman is credited for generating interest in the United States for the use of renewable energy as an alternative energy source. In 1952, his Paley Commission published Resources for Freedom which foresaw fossil fuel

shortages and strongly urged an aggressive solar research program. Few Americans listened.

Cheap and plentiful oil dampened interest in the use of renewable energy as well as in technological research and development. The oil embargo of 1973 and public interest in environmental issues sparked renewed interest in alternative energy sources. The Federal and state governments stepped in to encourage and incentivize the use of renewables. The late 1970s through the mid-1980s were a time of accelerated growth and interest in various types of renewable energy, but were followed by a precipitous decline when energy tax credits ended in 1985 and the price of oil dropped:

- Almost 14,000 wind turbines were installed. While California wind turbines generated 95 percent of the world's wind power in the mid-1980s, by the late 1990s, the state's share is expected to account for less than 50 percent of the total.

- 225 solar collector manufacturing firms shipped 17 million square feet of solar collectors annually by the mid-1980s. In 1991, there were 48 firms with annual collector shipments of 6.6 million square feet.

- Installed geothermal capacity was 311 megawatts in the mid to late 1980s and 40 megawatts of output capacity in 1992.

- Installed biomass power capacity was 840 megawatts in 1989 and 220 megawatts in 1991.

The war in Southeast Asia, international concern over the environmental impact of fossil fuels, and the need for energy efficiency in the competitive global market have once again spurred interest in renewable energy. The Energy Policy Act of 1992 supports development of renewable energy technologies and provides incentives to public power utilities for electricity produced from renewable energy resources through the authorization of a permanent 10 percent investment tax credit for solar and geothermal projects and a production credit for wind and biomass electric generating plants. Technological advances are making renewable sources more and more competitive. For example, wind power is competitive with conventional power generation in some areas. This most recent phase in the history of renewable energy may be more lasting and more productive than ever before.

## STRUCTURE

The renewable energy industry is the smallest sector of the energy market in the United States, except for nuclear power.

Table 2
1990 Total Energy Production
(Quadrillion Btu Per Year)

| Production | 1990 |
|---|---|
| Coal | 22.0 |
| Natural Gas | 18.5 |
| Petroleum | 17.9 |
| Renewable Energy | 6.5 |
| Nuclear Power | 6.2 |
| Total | 71.3 |

Each element of the renewable energy industry is small, with a few firms generating the majority of the business. There are a variety of ownership patterns. Generally the industry is comprised of small, private project developer-operators or independent investors. For example, of the 71 solar industry firms, the 10 largest firms had 95 percent of the total market. In the geothermal area, three utility entities that own and operate the installed geothermal power project at the Geysers, California geothermal field produce 54 percent of the total cumulative geothermal power capacity installed in the U.S.[1] Utilities, municipalities or county governments may also own renewable projects. Typically, this would be in the biomass (waste-to-energy) area. Large firms whose primary business is related to the renewable energy business are also involved in the industry.

One of the characteristics of the renewable energy area is the diverse number of products sold in each sector. For example, the solar industry manufactures high, medium and low solar thermal collectors and photovoltaic cells and modules to power the following: roadside billboards, highway directional signs and emergency telephones, navigational aids, remote lighting, remote stand-alone power systems, communication stations, water pumping and weather stations. Solar power cells power patio lights, portable radios and calculators. In addition, each sector produces specialized manufacturing equipment as well as designing and developing complete systems.

Conventional hydropower, geothermal, municipal solid waste, biomass, solar thermal and solar photovoltaic all produce electricity for residential, commercial or industrial use. In 1990, electric utilities in the United States used solar, wind, waste and geothermal energy to generate 10,651 gigawatthours of electricity. (A watthour is a unit of electrical energy equal to 1 watt of power steadily supplied to, or taken from, an electric circuit for 1 hour. A gigawatthour equals a billion watthours). However, it represents less than one-half percent of all the electricity produced by utilities, although another renewable energy source (hydroelectric) accounted for 10 percent.

While there are numerous examples of privately owned businesses that are profitable, the

[1]U.S. Industrial Outlook 1993, p. 8-13.

(hydroelectric) accounted for 10 percent.

While there are numerous examples of privately owned businesses that are profitable, the renewable industry as a whole is underutilized, unrecognized and underfinanced. It is difficult to secure financing for either new ventures or to take advantage of research and technology advances which may reduce production costs and improve efficiency. Renewable projects are also disadvantaged by the high interest rates required by lenders unfamiliar with the technologies. High interest costs are especially burdensome because renewable energy projects typically have high front-end costs.

The costs of initial market entry are high and the return on investment is frequently a long-term proposition. For example, a biomass waste-to-energy project may take 34 years due to an extensive legal permitting process which requires environmental impact statements, obtaining Qualified Facility status from the government, as well as negotiating power purchase agreements with utilities, sourcing the power generation and transmission equipment, interconnecting the project to the grid, and obtaining project financing.

## CONDUCT

Consumer demand for renewable energy in the United States depends on cost and availability of renewable energy sources and of alternative energy resources, commercial and residential electricity demand, financing availability, government regulations concerning energy and environment, and reliability.

There are numerous Federal and state laws and regulations which influence renewable energy costs, investment decisions and profits:

- Energy Policy Act of 1992
- Clean Air Act of 1990
- Public Utilities Regulatory Policies Act (PURPA) of 1978
- Public Utility Holding Company Act of 1935 (PUHCA)

The impact of these regulations influence renewable energy companies differently. Some may benefit indirectly from the government's emphasis and support for the use of renewables. For others, government regulations and decisions seriously affect all aspects of their business.

Federal and state governments influence the conduct of the renewable energy industry in several ways. Without government subsidies, tax and/or investment credits, renewable energy generated electricity does not always compete well with electricity produced by other means.

There is widespread belief among electric power producers that government regulations have a significant effect on the industry. The National Energy Strategy states that the Federal-State regulatory regime that governs investment decisions in electricity supply and demand will profoundly influence the types of new capacity to be built, who will build it, what technology and fuels are used, and what the full consumer and environmental consequences

delivering mature renewable products as well as developing new applications are the lifeblood of the renewable arena. For example, the technology for producing efficient wind turbines has advanced dramatically since 1981 when the first wind turbines were installed in California. The cost of wind turbines has dropped from $3,100 per kilowatt~our to $1,100 per killowatthour, with an increase in productivity that is nearly three times as great. Production costs for ethanol, an alcohol fuel made from biomass, have declined over the last decade from $3-$4 to $1.15-$1.60 per gallon.

The Federal government also provides research and development dollars to support renewable technological advances. The National Renewable Energy Laboratory (NREL) was designated as the Department of Energy's tenth national laboratory in 1991 to develop and commercialize new collector technologies. More research and development is needed. While scientists and engineers have developed technology to support a greater use of renewables as an energy producer, the missing link is the opportunity to translate R & D progress to practice, and realize that a continued, focused R & D is needed to understand the full potential of these technologies.

Government involvement in the renewable energy industry is not without its costs. Government decisions on what renewable energy R & D projects to fund is often based on location rather than desirability of the project. Government additions to the R & D budget often involve reallocating prioritized projects that may result in low, or no priority programs getting funded. Over time, the on-again-off-again support of the Federal government's national policies regarding renewable energy can result in a great deal of instability in the industry. This was confirmed during one industry visit when one company pointedly stated that it does not do any business planning based on potential government contracts because of their belief that good business practices and the government do not mix.

The Energy Policy Act of 1992 authorizes the following renewable energy incentives, with the goal of providing the consumer with cost-effective, renewable energy options that decrease our need for imported energy:

- A permanent 10 % investment tax credit for solar and geothermal projects.

- A production credit for wind and biomass electric generating plants.

- An extension of the Federal excise tax exemption for 10 % ethanol-gasoline blends.

Average costs for electricity from electric utilities produced from traditional fuels vary according to type of electricity used and location.

Table 3
Average Cents Per Kilowatthour
by Sector 1990
Electric Utilities

| | |
|---|---|
| Residential | .08 |
| Commercial | .07 |
| Industrial | .05 |
| Other | .06 |

The following table displays average cost data based on *An Alternative Energy Future*, a joint industry study. These data suggest that hydroelectric, geothermal and biomass projects are now competitive with electricity generated are now competitive with electricity generated from fossil fuels. However, average renewable energy costs are now competitive with electricity generated from fossil fuels. However, reported average renewable energy costs per kilowatt hour for the same energy source vary widely. For example, *U.S. Industrial Outlook 1993* states that most biomass projects produce electricity at 6-11 cents per kilowatt hour, and that most geothermal costs from 6-8 cents per kilowatthour.

Most industry analysts agree that renewable energy costs will decline over time due to efficiencies gained from technological advances. This downward trend is reflected in this table:

Table 4
Summary of Levelized Costs
Used for Renewable Technologies

(1989 cents/kWh)

| | 1989 | 2010 |
|---|---|---|
| Hydroelectric Power | .03 - .06 | .03 - .06 |
| Solar Thermal | .08 - .12 | .05 - .06 |
| Photovoltaics | .20 - .40 | .05 - .06 |
| Geothermal | .05 - .06 | .04 - .05 |
| Biomass | .05 | .05 |
| Wind Power | .07-.09 | .03-.05 |

## PERFORMANCE

The cost of renewable energy is projected to decline in the future. Use of renewable energy power in the United States is also expected to expand in most areas. Direct use of renewable energy in the form of alcohol, fuels, biomass (wood and municipal solid waste), solar, geothermal and wind is projected to grow at about 2.7 percent per year. The Department of Energy/Energy Information Administration's Annual Energy Outlook, January 1993 forecasts expanded use of renewables to generate electricity because of the incentives in the Energy Policy Act of 1992 and, to a lesser extent, because of the Clean Air Act Amendments of 1990. An exception is hydropower, which currently provides 10 percent of our electrical needs on a cost-effective basis. The environmental costs of hydropower will greatly inhibit its expansion in the United States in the future.

There is tremendous potential for U.S. renewable energy power and products in the international arena--particularly in developing countries. U.S. firms have a competitive edge in most aspects of renewable energy project design, planning, operation and management. U.S. firms are also very experienced and knowledgeable in profitable private power development. The U.S. will compete for business in Asia, Eastern European countries, the newly independent states of the former Soviet Union, as well as Chinese, German, British, Italian and Japanese firms.

Renewable energy statistics are poor for a variety of reasons: imprecise measures, poor reporting mechanisms, and various equipment categories captured within other categories. There are no reliable production or export statistics for many renewable energy products or systems. Many of the components fall into existing general SIC categories of electric power generating equipment and cannot be analyzed separately.

## POLICY ISSUES

Although renewable energy is abundant, clean and available, it is often site-specific. Deserts and waterfalls are not normally loca‹‹d in highly dense, populated areas, nor are the very large areas of open land required for v and solar energy production. The difficulties of transporting the energy produced from ren ıble sources over long distances is a serious drawback to widespread use of renewables.

Renewable energy will not replace any other energy source or eliminate energy imports in the foreseeable future. What renewable energy can do is effectively offer a range of alternatives to mitigate the negative effects of other energy sources. The latest national policy emphasis on renewables, as reflected in the Clean Air of 1990, the Energy Act of 1992, and the National Energy Strategy, represent positive approaches to increasing use of renewables where market forces and consumer preferences tend to favor more fossil fuel consumption.

Increasing exported renewable energy technology could provide jobs for Americans and reduce the balance of trade. Aggressive Federal government involvement is needed now to ensure that the United States is able to compete fairly and openly in the world market.

# ENERGY SECTOR: COAL

## HISTORY

Coal was reportedly used by the Indians of the Southwest long before the early explorers arrived in America. The first record of coal (in what is now the United States) was found on a map prepared in 1673-74 by Louis Joliet. It shows "charbon de terra" along the Illinois River in northern Illinois. About a quarter century later, in 1701, coal was discovered near Richmond, Virginia. (In 1784, the first commercial coal production came from that area). A map drawn in 1736 shows the location of several "cole mines" along the upper Potomac River, what is now the border of Maryland and West Virginia. Before the end of the 1750s, coal discovery was reported in Pennsylvania, Ohio, Kentucky and West Virginia. Anthracite was found in Pennsylvania about 1762.

In colonial days, blacksmiths used small amounts of "fossil coal" or "stone coal" to supplement the charcoal normally burned in their forges. Farmers dug coal from beds exposed at the surface and sold it by the bushel. Although most of the coal for the larger cities along the eastern seaboard was imported from England and Nova Scotia, some came from Virginia.

By the late 1800s, coal became the principal fuel used in locomotives. Coal became a growing market as fuel for households and steamboats. The coke industry in the United States began in the latter half of the 1800s and, in the 1860s, replaced charcoal as the chief fuel for iron blast furnaces. Coal was also used to produce illuminating oil and gas. Baltimore, Maryland was the first city to use gas made from coals to light streets. Briqueffing of coal was introduced in the United States about 1870. Coal-fired steam generators began to produce electricity in the 1880s. Thomas Edison developed the first practical coal-fired central electric generating station and, in 1882, was put into operation in New York City to supply electricity for household lights.

In the earliest mines, coal was carried from beds that were exposed to the surface. To get more coal, the miners had to follow the coal bed underground. Before coal-cutting machines became available in the late 1800s, coal was mined underground by hand. Mechanical coal loading equipment introduced in the early 1920s replaced hand loading and increased productivity. Mules, and to a lesser degree, horses and oxen, were used to haul coal and refuse in and around the early mines; a few dogs were used in small mines working thin coal beds. In time, the animals were replaced by electric locomotives, dubbed "electric mules," and other haulage equipment.

Strip mining began in 1866 near Danville, Illinois, when horse-drawn plows and scrapers were used remove the overburden so the coal could be hauled away in wheelbarrows and carts. In 1877, the steam-powered shovel excavated some ten feet of overburden from a three-foot thick coal bed near Pittsburg, Kansas. In 1885, a converted wooden dredge with a fifty-foot boom was used to uncover a coal bed under thirty-five feet of overburden. in 1910, surface mining was underway, using steam shovels specifically designed for coal mining.

Coal has played an important role in the development of the United States. In the early 1900s, coal was so widely used that it reigned as the nation's principal source of energy.

Later, the dependency on coal declined in the face of competition from oil and natural gas, which are cleaner and easier to use. Eventually, the coal industry lost the business of railroads as coal consumers, nearly all of the home heating market, and much of the smaller industries.

The Arab oil embargo of 1973 underscored the nation's precarious dependence on foreign oil and renewed interest in the vast, widely distributed domestic coal deposits. Since then, the market for coal has improved almost steadily, and the production and use of coal have reached unprecedented levels. Through its role in generating electricity, coal has indirectly recaptured part of the market it lost years ago.

Today, the United States is prominent as both a producer and exporter of coal. In 1990, an average of more than 2 million tons of coal were consumed daily to help satisfy the nation's demand for energy. About 130,000 persons worked in over 3,400 mines to produce this coal, valued at about $22 billion. $4 billion of that was exported.

About 55 billion tons of coal have been produced in the United States since the first commercial mine was opened more than 200 years ago. Even so, U.S. coal deposits still contain more than 200 billion tons of minable coal, a reserve of energy that contributes to the nation's security.

## STRUCTURE

### Mining

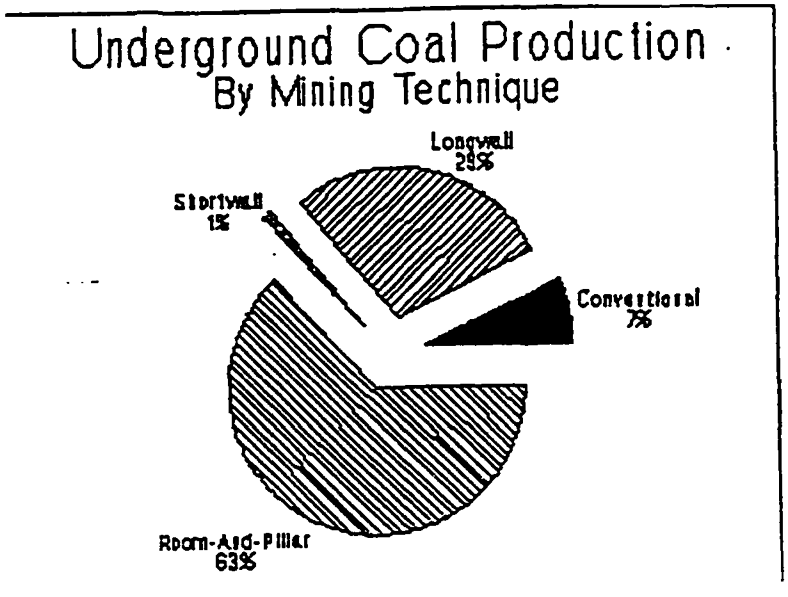
The industry is composed of establishments primarily engaged in producing and developing bituminous coal or lignite at surface mines, Standard Industrial Classification Code (SIC) 1221, bituminous coal, or lignite at underground mines (SIC 1222), and anthracite (SIC 1231). The industry consists of underground mining, auger mining, strip mining, culm bank mining and other surface mining. It includes coal preparation plants engaged in clearing, crushing, screening or sizing. It also includes establishments that primarily perform coal mining services for others on a contract or fee basis (SIC 1241).

The mining method used depends on the depth of the coal bed from the surface and the character of the terrain. Coal beds deeper than 200 feet are usually mined by underground methods. Those that are at shallower depths are worked by surface methods.

**Underground mining** is accomplished by three basic techniques: room-and-pillar, longwall and shortwall. Frequently, several techniques are used simultaneously in different sections of a mine. Sixty three percent of the minable underground coal is recovered by the room-and-pillar method.

The second most important technique of underground coal mining is longwall mining, which is gaining importance in the United States and can be used at greater depths than room-and-pillar mining. Longwall mining is done under moveable roof supports that are advanced as the bed is cut. The roof in the mined area is allowed to fall as mining advances. Production of coal per shift from longwall mining is generally more than double that of the room-and-pillar technique. It is also safer because the working area is protected by overhead

steel supports.




About 100 longwall mining systems are operating in the United States, most of them in the Appalachian Region.

The third technique of shortwall mining, used in relatively few mines. Productivity with this method is lower than longwall mining because the coal is hauled by shuttle cars rather than by conveyor.

**Surface mining,** also called strip mining, is the least expensive mining method and usually the only safe and efficient way of mining coal at depths of less than 200 feet. Surface mining is also less restrictive than underground mining, because equipment can be easily moved. Coal recovery rates at surface mines can exceed 90 percent.

Surface mining is essentially large-scale earthmoving that consists of excavating the overburden from the coal bed, then removing the coal. The amount of overburden excavated per ton of coal recovered ranges from 1 to more than 30 cubic yards. In general, the best, or lowest ratios are in the western mines.

**Production**

The coal industry is relatively unconcentrated. The largest producer of U.S. coal, the British-owned Peabody Coal Company, accounts for less than 10 percent of the market. The next largest coal producers in 1991 were Consol Energy, Amex, Exxon Coal, Texas Utilities, and Arco Coal. The top 20 firms account for slightly more than 50 percent of the aggregate production. The privately held Zeigler Coal Company purchased the U.S. coal operations of the Royal Dutch/Shell Group in 1992 and many of the coal operations of British Petroleum in 1991. In 1992, Zeigler became the fourth largest coal company In the United States.

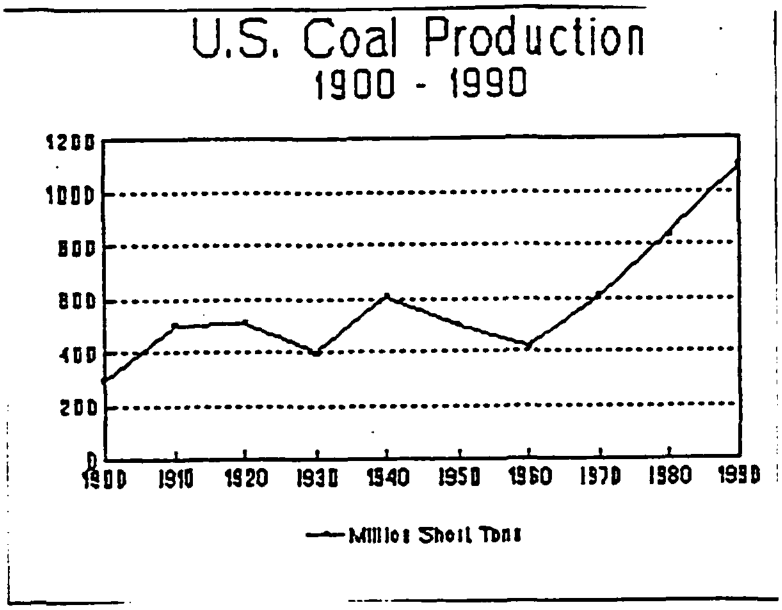
In recent years, new mining technology has gradually transformed the industry. The expanded use of longwall techniques and large scale surface mining have enabled the industry to steadily raise production even as prices, the number of mines, and the level of employment have fallen. Because new technologies require large initial capital investment, they tend to be used more by large firms. Although there are over 3,000 coal mines in the United States, 64 percent of domestic production now comes from 211 large mines, with an annual production greater than 1 billion tons per year.

Western coal tends to be low-sulfur, low-energy content coal produced from huge surface

mines. Eastern coal has a high energy content, but is mined by diverse techniques, and its sulfur content varies widely. While output from mines east of the Mississippi increased only 2 percent from 1980 to 1991, output west of the Mississippi grew 61 percent and now accounts for 41percent of U.S. production. The recession has hit eastern coal hardest. Output slumped 6 percent in 1991, while western production rose.

**Employment and Productivity**

The number of workers employed in the coal industry has declined so dramatically that the current coal mining labor force is less than one-third the size from a century ago, despite record levels of production. In contrast with 400,000 to 800,000 coal workers employed in mining from 1900 to 1950, the number totaled about 130,000 in 1991. This drop is attributed to the replacement of manual labor by machines in virtually all phases of mining, and an increase in surface mining that requires fewer employees.




**Health and Safety**

Coal mining, particularly underground coal mining, is a dangerous occupation. Although the Federal Government has been involved in mine safety since 191 0, it was not given inspection powers until 1941. In 1952, it was authorized to set mandatory safety standards for underground coal mines. The Federal Coal Mine Health and Safety Act of 1969 vastly increased the Government's enforcement powers by mandating fines for violations, authorizing criminal penalties for intentional violations, and enabling miners to request safety inspections. Inspections are made by the U.S. Department of Labor, Mine Safety and Health Administration.

**Preparation**

Most of the coal produced in the United States receives some degree of processing before it is used. The amount of processing depends on the customer's specifications. Some coal is blended at the mine. About two-thirds of the coal mined in the east for electric power plants is cleaned; whereas, most of the coal shipped to electric utilities from western mines is generally only crushed and screened to facilitate handling and to remove extraneous material introduced during mining. By comparison, nearly all of the coal used to make coke for steelmaking undergoes a high level of cleaning.

**Transportation**

The coal industry depends heavily on the transportation network for delivering coal to customers across the country. Frequently, coal deliveries are handled by several different modes before finally reaching the consumer. The flow of coal is accomplished by railroads,

barges, ships, trucks, conveyors and slurry pipeline.

Railroads are the foundation of the coal distribution system, delivering about 60 percent of the coal distributed to domestic customers and export terminals each year. ore than half of railroad coal shipments are made by unit train, comprised of up to four locomotives and 100 to 110 cars. The unit train can be loaded with 10,000 to 11,000 tons of coal in 2.5 to 3 hours and unloaded in 4 to 5 hours.

Waterborne coal shipments rank next to railroads in coal shipments, accounting for nearly 2 out of every 10 tons of coal shipped annually to domestic markets. Coal deliveries by truck account for about 1 out of every 10 tons of coal shipped. Trucks are used for short hauls; generally less than 50 miles. Aerial tramways, conveyors, and coal slurry pipeline together account for the same amount of coal deliveries as trucks.

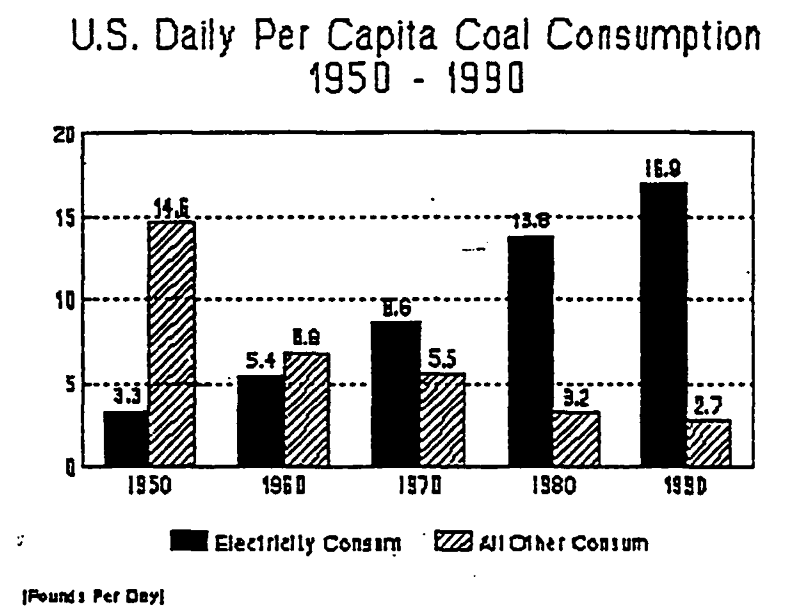
**Supply and Stocks**

In recent years the supply of coal from the mines has averaged nearly 19 million tons per week, although this rate can vary considerably. Sharp rises reflect greater demand, such as that caused when coal-fired electricity generation is increased to offset a drop in hydroelectric generation during periods of low water. As insurance against a disruption in deliveries, large coal consumers generally maintain a 60 to 90-day stockpile of coal.

**Use**

The principal domestic market for coal is the electric utility industry. Coal generates over half the U.S. electric power, and more than three quarters of U.S. coal production is sold to electric utilities. An additional 11 percent is exported. Metallurgical coal used in the U.S. steel industry accounts for about 3 percent of production. The balance is used in industries other than steel, and in the residential, commercial and transportation sectors.

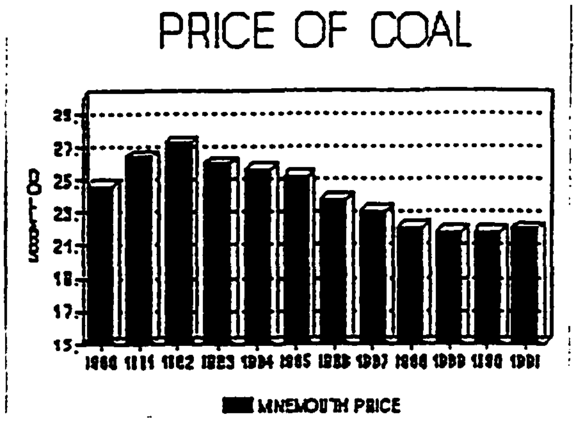
Coal is used in all 50 States. In 1991, 10 States accounted for about 52 percent of the total coal consumption. Of these, Texas, Indiana, Ohio, and Pennsylvania were predominant, with a combined share of 30 percent.




The use of coal in the United States has risen almost steadily since the early 1970s, reaching record levels and totaling 894 million tons in 1990. Virtually all the growth has been due to the increasingly larger amounts of coal used to generate electricity.

## CONDUCT

### Prices




Due to the cost advantage that coal offers over oil and gas, the amount of coal used by utilities annually has trended upwards. Rising from less than 400 million tons per year during the early 1970s to 772 million tons in 1990, the growth in the use of coal for generating electricity has generally kept pace with the growing demand for electricity. The price of coal is determined by its transport cost, its energy content per unit weight (in British Thermal Units) and its sulfur content. Sulfur content is important because when burned, the sulfur in coal 6 produces polluting sulfur dioxide gas, one of the key precursors to acid rain. Coal with low sulfur content (coal that emits less than 1.2 pounds of sulfur per million BTU's) is called "compliance coal" and commands a premium price. The average minemouth price of coal is presently $22.00 per short ton.

### Buying Practices of Consumers

Electric power producers purchased 772,560 million tons of coal, which accounts for 87% of domestic consumption. The industrial/retail market purchased 79,920 million tons (9%) and the remaining 35,520 million tons (4%) was consumed by manufacturers of iron and steel. One hundred and nine million tons of coal was exported in 1992, bringing the total demand for American coal to 997 million tons.

### Labor Practices

The coal miners are among the nation's best paid, most skilled and productive workers. They average about $38,000 per year in salary and many make considerably more when overtime and production bonuses are figured in. Since 1980, the coal workforce has decreased from about a quarter of a million to a level of slightly above 131,000. This decline has been due to mining operations becoming more mechanized and computerized; the closure of uneconomical or unproductive mines; the expansion of less labor-intensive surface mining; and the increased use of longwall mining that requires fewer workers than traditional deep mining methods. Almost two-thirds of the total number of coal miners work in underground operations.

### Government Regulations

There are numerous government regulations dealing with mining. These regulations are enforced by the Federal Mine Safety and Health Administration (MSHA). Each year MSHA regularly inspects each underground mine four times, each surface mine two times and conducts numerous unscheduled spot inspections to assure compliance. Government

regulation has helped to improve coal mine health and safety. The incident rate for injuries has remained at around 10 incidents per 200,000 employee hours for the last five years, and the fatality rate has remained at around .05 per 200,000 employee hours for the last three years.

**R & D**

The coal industry is actively involved in research and development of coal technologies. One program is the Department of Energy's Clean Coal Technology Demonstration Program, which is a $5 billion, cost-shared, national commitment designed to promote innovative technologies for energy-efficient and environmentally sound use of coal. Another Department of Energy research and development program is directed to commercialize the use of coal derived liquids or gasses in diesel engines.

## PERFORMANCE

### Trends

COAL MINE PRODUCTIVITY

| YEAR | MINERS | AVERAGE OUTPUT |
|---|---|---|
| 1980 | 224,938 | 1.94 |
| 1982 | 214,400 | 2.14 |
| 1984 | 175,716 | 2.65 |
| 1986 | 152,668 | 3.04 |
| 1988 | 135,366 | 3.55 |
| 1990 | 131,306 | 3.83 |

Output in average tons per miner per hour

There are several important trends in the coal industry. The first is the average minemouth price of coal per ton. The present average minemouth price as reported by the Energy Information Administration is $22.00. This is the ninth straight year of decline. But the average delivered price of coal (in 1990 dollars) to all consuming sectors is projected to rise gradually from $22.00 per ton in 1990 to $32.00 per ton in 2010. The second important trend is the average number of miners working daily and their productivity. As shown below, the average number of miners working daily has decreased from 224,938 in 1980 to 131,306 in 1990, while their average productivity has increased from 1.94 tons of coal per miner per hour to 3.83 tons of coal per miner per hour. Increased mechanization and training are responsible for this trend.

### Exports

U.S. coal exports totaled about 109 million tons in 1992, or 11 percent of production. Metallurgical coal, used in steel production accounts for more than half of U.S. coal exports. Metallurgical coal is primarily sold to Japan, Western Europe, Brazil and Canada, and commands a substantial price premium over ordinary (steam) coal. Steam coal is used primarily as boiler fuel and is sold primarily to Western Europe, Canada, Taiwan and Japan. American coal producers ship their product to some 50 countries and generate more than $4 billion annually on the positive side of the nation's trade balance.

For publicly traded firms, which represent about half of the coal industry, net income rose about 4 percent in 1992. Capital expenditures for publicly traded firms increased 19 percent to $1.9 billion.

## INDUSTRY ISSUES

Coal represents America's most abundant and inexpensive source of energy. Estimated reserves in the U.S. represent about 250 years of output at an annual rate of one billion tons. For this reason, many policymakers have proclaimed coal as the key to U.S. energy independence--a goal sought by successive administrations since the 1973 oil embargo. The reasons why coal has not become a more dominant energy source are the escalating costs and market constraints resulting from environmental concerns, safety concerns, and non-competitiveness of synthetic fuels.

### Environmental Concerns

Coal is dirty. As a result, there are many undesirable environmental consequences from the mining, distribution, storage and burning of coal. These environmental consequences can be categorized according to the medium affected: air quality, water quality, land reclamation, and global warming.

***Air Quality.*** The combustion of coal can result in adverse impacts on air quality. Coal contains sulfur. When coal is burned, sulfur combines with oxygen to produce sulfur dioxide. When sulfur dioxide combines with water vapor it produces sulfuric acid, a component of "acid rain."

The 1970 Clean Air Act (CAA) established limits for sulfur dioxide emissions from coal--fired power plants. The 1977 amendments to the CAA added a further requirement that plants built or altered after 1978 would have to reduce sulfur dioxide emissions by 70% to 90% from the levels that would be emitted had no controls been established. To meet these standards, coal-fired plants have taken four basic approaches: pre-combustion removal (benefication) of sulfur; post-combustion removal using a flue gas desulfurization system--or "scrubber"; burning low sulfur coal; and coal blending--mixing coals with varying sulfur content.

Meeting the 1977 ACC amendments standards required the installation of scrubbers on coal-fired plants built after 1978. Thus, two categories of coal-fired power plants were created: those built before 1978 that have little or no pollution control equipment and those built after 1978 with scrubbers. Currently, there are about 82 coal-fired plants in the U.S. equipped with 146 scrubbers. There are 110 plants generating 15 percent of total U.S. power generation capacity, with little or no pollution controls (built before 1978).

The nation's clean air laws were tightened again with the 1990 Clean Air Act Amendments (CAAA). The CAAA establishes sulfur emissions controls in two phases: phase I controls set out specific 1995 sulfur dioxide emissions limits for the 110 older power plants. Phase II controls impose a permanent cap of 8.9 million tons per year on sulfur emissions from all U.S. electric utilities after the year 2000. In effect, all new power generators that burn fossil fuels after 2000 will have to stay within the sulfur emissions cap--either offsetting sulfur releases from new plants by cutting emissions at existing plants or by purchasing emissions "credits"

from utilities that exceed the sulfur dioxide reduction requirements. Thus, these standards affect the choice of fuel (coal, oil, natural gas) and technology to be used at all existing and future power plants to be built in this country. Clearly, the future competitiveness of the coal industry, which has a higher sulfur content than both oil and natural gas, is dependent on the viability of emerging "clean coal technologies."

Clean coal technologies represent a fundamental change in coal-fired power plant technology. These technologies have the potential to make a coal-fired plant as clean as plants that burn oil and natural gas. Further, these technologies improve a plant's operating efficiency (performance), unlike traditional scrubbers which reduce efficiency by 3 to 8 percent. Clean coal technologies fall into four categories:

**Precombustion:** Technologies which remove sulfur and other impurities before the coal reaches the boiler. These advanced processes improve the effectiveness of physical cleaning or washing, or employ chemical or biological techniques to remove sulfur and ash.

**Combustion:** Technologies which remove pollutants inside the combustor while the coal burns. Most research in this area has focused on atmospheric and pressurized fluidized bed combustion, advanced combustors, and limestone injection multistage burners.

**Post-Combustion:** Technologies which clean flue gases emitted from coal burning and generally located in the ductwork leading to the smokestack, or in advanced versions of present-day flue gas desulfurization systems (scrubbers). Alternatives include in-duct sorbent injection and catalytic reduction systems.

**Conversion:** Technologies which change coal into a gas or liquid that can be cleaned and used as a fuel. The most promising include integrated gasification combined cycle and coal-oil co-processing.

Without clean coal technologies, coal could be noncompetitive with other fuels. Installing scrubbers (existing technology) on all pre-1978 power plants could impose additional costs as high as $300 per kilowatt. Further, by the mid-1990s more than half of all existing coal-fired boilers in the U.S. will be 30 years old or older. At the same time, demand for electricity is rising. Unless new coal technologies are developed and made available, utilities may have little choice but to convert to alternative fuel sources or close.

***Water Quality.*** Coal producers spend millions of dollars to contain, treat, or prevent damage to ground and surface waters. These actions are taken to comply with two primary federal laws--the Clean Water Act (CWA) and the Surface Mining Control and Reclamation Act (SMCRA)--as well as state and local statutes.

The Clean Water Act sets coal mine water discharge limits. It requires the mines to sample and analyze water quality regularly and provide the data to EPA and other state/local regulators. SMCRA sets stringent quality standards for water discharged from mining operations. Like CWA, it requires water sampling and monitoring timetables.

The major water quality areas of concern for the coal industry include acid mine drainage control, ground water protection, and prevention of surface water sedimentation.

**Acid Mine Drainage Control:** When exposed to air and water, the pyrite or iron disulfide present in coal will oxidize, producing ferrous ions and sulfuric acid. When oxidation of pyritic materials and their dissolution in water occur, the result is a liquid that is toxic to aquatic life. Acid mine drainage is not a widespread problem. it is confined mainly to specific geographic regions where there are old, abandoned, underground mines. Government and industry researchers are making strenuous efforts to find efficient and cost-effective solutions to control and mitigate this problem. The most commonly used mitigation program involves the continual addition of alkaline materials to affected waters to neutralize acidity. The discharge is treated and transported to a sedimentation pond. More advanced treatment processes are currently under development.

**Ground Water Protection:** Like coal, ground water is located at various depths from the surface. Coal extraction modifies the ground water system around a mine. In most cases, a virtually unpreventable effect is the seepage of ground water into the mine site. This flow causes changes to the water table and can cause changes to water chemistry as soluble components dissolve in the ground water. From an overall perspective, coal mining is not a major user of ground or surface waters, and the extraction of coal does not often disrupt water sources. The effects are usually temporary and impacts can be minimized through continual monitoring, assessments, and reclamation activities.

**Sediment Control:** Coal extraction requires the movement of large quantities of earthen materials. Layers, once deeply buried, are brought to the surface to be deposited temporarily, especially during surface mining. These exposed and unstabilized earthen deposits are subject to runoff and erosion, and can become the source of chemical and/or physical alteration of local streams. Sediment is controlled through careful planning and design of measures to reduce soil erosion. Disturbed areas are graded, and some areas terraced to achieve stable slopes, reduce runoff water velocity, increase filtration, and divert runoff into drainage channels. Further, sedimentation ponds can be used to minimize the amount of sediment leaving a mining site.

**Land Reclamation**. Regulated under the Surface Mining Control and Reclamation Act of 1977, comprehensive and effective reclamation has become a standard and integral part of coal mining operations. Before a company can begin extracting coal, a multitude of government permits are required. These permits require extensive analyses of the mining site to control sedimentation, protect ground and surface waters, protect archaeological artifacts, and determine how soil will be removed and revegetation achieved. Once information is compiled, the coal company files a permit application. SMCRA requires a period of time for public review and comment and company response to public concerns before the government issues a permit.

Since SMCRA was passed, an estimated 2.5 million acres of mined lands--an area larger than the state of Delaware--has been restored to productive use. In addition, more than 100,000 additional acres of abandoned mines have been reclaimed through money paid by today's coal producers into a national trust fund. Environmental stewardship has become an important aspect of mining operations and must be considered an integral part of doing business.

***Global Warming***. Another environmental issue of importance to the coal industry is potential global climate changes caused by the emission of so-called greenhouse gases. Scientific studies have shown that the percentage of carbon dioxide in the earth's atmosphere has been steadily rising. Carbon dioxide is one of several gases that tend to absorb reflected solar radiation, trapping the sun's heat within the atmosphere. This process may cause the average temperature of the planet to rise, causing uncertain, but potentially drastic, changes in global climate.

All fossil fuels, when burned, emit carbon dioxide. However, coal emits 80 percent more carbon dioxide per unit of energy consumed than natural gas, and about 20 percent more carbon dioxide than fuel oil. Hence, coal-fired power stations are prime candidates for controls on carbon dioxide emissions.

Currently, the U.S. government has not committed to controlling/limiting the growth of carbon dioxide emissions (at least not formally). There remains scientific uncertainty over the existence and extent of global climate change. Thus, no actions affecting the coal industry are likely for some years to come. However, when the issue resurfaces, limitations on carbon dioxide emissions could prove to be very costly to the coal industry--both in dollars and in market share of coal use for power generation.

**Health and Safety Concerns**

The high risks of coal mining--including black-lung disease, explosions, and cave-ins (subsidence)--give it the highest worker death rate of any industry. It is not surprising that miners are among the most militant rank-and-file workers in the country. In 1969 Congress passed the Coal Mine Health and Safety Act which established strict rules for an industry that had a poor record of protecting its workers. These new safety measures reduced productivity while miners and their employers adjusted to new operating procedures.

**Strip Mining**. One outgrowth of the new standards was the shift in emphasis from the traditional deep mines of Appalachia, with their militant labor force, to expanding the Western open-pit extraction. This strip-mining involved less labor and was considerably more productive and safer than tunneling.

***Long-Wall Mining***. Meanwhile, attention was focused on solving the age-old problem of subsidence--the gradual movement or sometimes abrupt collapse of the rock and soil layers into an underground coal mine. The most prominent outgrowth of this was the emergence of a new technology to replace the traditional "room-and-pillar" technique of extraction from underground mines. The safer, more productive, "long-wall" mining technique--which utilizes a rotating shear on a mining machine that moves back and forth across a long coal seam--was developed. However, long-wall mining currently accounts for only a third of total underground coal production. The room-and-pillar technique, with its inherent risks, is still the predominant technique used in underground mines today.

***Funding Health Benefits***. The rise in Western strip-mining has had an effect on the financing of pension and health benefits of retired mine workers. Western coal is usually mined by non-union workers, while eastern coal is a stronghold of the United Mine Workers of America Union. As the number of union workers in the industry has declined, the cost of

financing pension and health benefits has become a proportionally greater burden on current companies and remaining union workers. In 1992, Congress adopted legislation to help fund benefits for retired union miners whose firms have ceased to exist, left the industry, or converted to non-union work forces. Contributions will be extracted from former employers, other pension funds, and a federal trust fund originally established to pay for mine reclamation.

### Non-Competitiveness of Synfuels

One of the bases for optimism in the coal industry in the late 1970s was the sudden interest for synthetic fuels, particularly oil and gas derived from coal and oil extracted from shale. In 1979, amid the second oil shock, President Carter proposed an $88 billion, 10-year program to produce 2.5 million barrels of synthetic oil daily by 1990. In 1979 Congress appropriated $17.5 billion for research and created the Synthetic Fuels Corporation to administer the work.

The Federal government enthusiasm for synfuels waned under President Reagan, largely due to the easing of the oil crunch. The $2 billion Great Plains coal gasification plant built in North Dakota by a consortium of five energy companies was written off by the owners. Slumping oil prices and Federal budget cuts crippled the Synthetic Fuels Corporation and, in 1989, the agency was shut down. The future of synfuels appears dependent on the future availability and pricing of oil and gasoline, which should remain relatively stable through the 1990s.

## CONCLUSION

The expansion of the coal industry is already colliding with the increased costs of doing business--ameliorating the environmental side effects of coal use and improving the health and safety of mine workers. At present, the cost of meeting the 1990 Clean Air Act Amendments is the most significant issue and will add considerably to the cost of using coal for power generation, unless clean coal technologies become available soon. In the longer run, if carbon dioxide emissions are restricted or taxed, the coal industry will bear the brunt.

## ENERGY INDUSTRY OUTLOOK

Presuming to project an "energy future" is dangerous business, as the perturbations of 1973-74 and 1979-80 so vividly attest. Moreover, the fact that national energy supplies are provided by a web of dissimilar companies, using a variety of mature and emerging technologies, further complicates any attempt to accurately predict future trends. Energy is such a critical element of the economy that it is sometimes difficult to appreciate the fact that obscure events in faraway places can have dramatic effects on our energy use.

One approach is to extrapolate the present situation and current trends into the future, while maintaining a cautious recognition that any of a number of events can change the picture dramatically. Using a foundation assumption that world oil prices will remain relatively stable, we can venture the following general outlook to 2010:

- Domestic oil production and domestic reserves, will continue to decline, drawing

increased imports not only of crude oil, but increasingly of refined products as well.

- Stable price levels and environmental concerns will preclude significant oil and gas exploration and development in the most promising domestic areas, i. e., the Arctic National Wildlife Refuge and promising offshore regions.

- Oil will continue to be the most important energy source for transportation, relinquishing its hold only gradually as California requirements draw electric, natural gas and methanol-fueled vehicles into increasing USB toward the end of the period.

- Natural gas will supplant oil and, to a lesser degree, coal in electric power generator, limited only by the ability to expand the gas pipeline system.

- Coal will remain principally a fuel for electric power generation, but will slowly lose market share in this energy sector because of the pollutants generated and the large investment needed to reduce them. Coal's competitiveness will continue to benefit from its clout in the political process.

- Burdened by aging, one-of-a-kind plants and lacking a long-term solution to the waste storage problem, nuclear reactors will generate a gradually declining proportion of electric power.

- Assisted by a more activist government role, renewable energy technologies will move increasingly beyond laboratory R & D into full-scale demonstration and production projects. Renewables will show a steady increase in their share of total energy, but offer no panacea for difficult energy policy choices.

- Wind power, now commercially feasible in certain areas of the country, will be developed to augment the power grid.

- Central solar plants will be developed for electric power in the Southwest.

- Use of photovoltaics will blossom in niche markets, especially where the expense of connecting to the power grid is significant.

- Because of "energy awareness" developed over the last two decade and efficiency guidelines promulgated at the state and local levels, energy efficiency per unit of gross domestic product will continue to improve.

Again, we caution that this very general assessment may be skewed by unforeseen events. A precipitous change in the price of oil would be the most dramatic. It could be argued that a drop in oil prices might have the most adverse effect on national security: if uninterrupted by government action, domestic production would probably drop dramatically, increasing dependence on foreign sources while discouraging development of new technologies.

## POLICY ISSUES AND OPTIONS

Viewed as a whole, the nation's usage of energy from many sources can be characterized as an "energy portfolio." Much like a collection of investments, the national energy portfolio can, to a certain degree, be managed to achieve desired results.

For the policy maker, the energy portfolio offers an interesting menu of choices and trade-offs:

· **Coal** is in plentiful domestic supply, but is dirty and inconvenient to use in its natural state.

· **Oil**, so crucial to the transportation sector for its convenience and high energy content, is moderately polluting and ties the United States to problematic foreign policy choices.

· **Natural gas** is the cleanest of fossil fuels and has reasonably available domestic reserves, but becomes inconvenient to use beyond the reach of the pipeline system.

· **Renewables** offer an array of proven and speculative energy sources, with promises and limitations tied to the state of technology, geography, time of day and other factors.

We believe that two significant policy issues confront the nation: *energy security* and *environmental concerns.*

*Energy security* has been a watchword since the 1973 embargo put incredulous and panicked Americans into long gasoline lines. As it was twenty years ago, the problem is overwhelmingly concerned by oil. Because virtually all modes of transportation rely on petroleum-based fuels, the issue of energy security translates primarily into risk for the nation's transportation system.

Clearly, then, improving our energy security depends on reducing the predominance of oil as an energy source for the transportation sector. Although the Federal government has taken some steps--such as instituting a Strategic Petroleum Reserve--the United States remains heavily dependent on imports of foreign oil and will grow more dependent in the future if present trends continue.

Growing environmental concerns have surpassed the localized issues of clean air and water to encompass the more widespread effects of acid rain and global warming. As a consequence, fossil fuels have been stigmatized to varying degrees--coal being the worst, natural gas the best--for the carbon they introduce into the atmosphere. Despite their reputation as "clean" energy sources, renewables generally involve environmental trade-offs as well. For example, biomass produces carbon, and construction of large wind farms and solar thermal plants may affect ecosystems where they are located. On balance, however, renewable sources offer significant environmental advantages.

**Policy Recommendations**

We believe government policy should support movement toward greater energy security and an improved global environment. Reduction in our reliance on imported oil will clearly improve the national security posture of the United States. Although environmental issues are tied less directly to national security, environmental improvements are clearly in the long-term

improve the national security posture of the United States. Although environmental issues are tied less directly to national security, environmental improvements are clearly in the long-term national interest.

Unfortunately, these goals can be contradictory, as shown by the fact that some of our most promising domestic oil and gas territories have been placed off-limits for environmental reasons. Moreover, previous attempts by the Federal government to manage the energy industry have had very mixed results. Regulation of natural gas and the costly synthetic fuel and oil shale projects are recent examples.

Government initiatives must, therefore, concentrate on actions that will adjust the nation's energy portfolio without destroying the efficiencies of the market, and which will avoid spending scarce resources on uneconomical projects based solely on massive government subsidies.

Specifically, we recommend:

- Enactment of the proposed Btu tax, which penalizes oil use more heavily than other forms of energy and provides a slight advantage for renewable energy development.

- Establishment of limited tax credits for investment in full-scale solar and wind energy projects.

- Encouraging government laboratories to develop appropriate energy technologies--such as improved batteries and energy storage systems--that may have downstream defense applications as well.

- Maintaining the Strategic Petroleum Reserve as a hedge against unforeseen disturbances in oil prices.

- Consider adopting California requirements, or other incentives, to have significant numbers of "zero emission vehicles" on the road by 2010.

These measures will help guide the nation's energy portfolio toward a more secure energy future.

# INDUSTRY STUDIES

# #5

# ARMAMENTS

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## PARTICIPANTS

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## PLACES VISITED

### Domestic

| | |
|---|---|
| BEI Defense Systems | Camden, AR |
| Beretta, USA | Accokeek, MD |
| Naval Surface Warfare Center | Dahlgren, VA |
| USAF Weapons Systems Command | Eglin AFB, FL |
| HITECH | Camden, AR |
| Louisiana Army Ammunition Plant | Minden, LA |
| Loral Vought | Camden, AR |
| Naval Ordnance Station | Louisville, KY |
| Picatinny Arsenal | Dover, NJ |
| Pine Bluff Arsenal | Pine Bluff, AR |
| Radford Army Ammunition Plant | Radford, VA |
| Tracor | Camden, AR |
| Watervliet Arsenal | Watervliet, NY |

### International

| | |
|---|---|
| British Aerospace, Dynamics | Stevenage, UK |
| Deutsche Aerospace, Corporate Headquarters | Ottobrun, GE |
| Deutsche Aerospace | Schrobenhausen, GE |
| Deutsche Aerospace | Nabern, GE |
| Giat, Corporate Headquarters | Versailles, FR |
| Giat | Bourges, FR |
| Ministry of Defense, France | Paris, FR |
| Ministry of Defence, United Kingdom | London, UK |
| Royal Ordnance | Nottingham, UK |

# INDUSTRY STRUCTURE AND CONDUCT

## STRUCTURE

### Definition of the Armaments Industry

The armaments industry provides a wide variety of products with capabilities spanning the entire conventional warfighting spectrum of our nation's armed forces. These products range from simple small arms ammunition to sophisticated, precision guided munitions. Armament products can be segmented into five broad categories:

- Small arms and specialized munitions: bullets, flares, and signalling devices (SIC 3482, 3812).

- Ammunition other than small arms: artillery and naval gun projectiles, armored vehicle cannon rounds, free fall bombs, and mines (SIC 3483).

- Missiles and rockets: surface-to-air, air-to-air, air-to-ground, and surface-to-surface (includes cruise missiles) (SIC 3769).

- Small arms weapons: pistols, rifles, machine guns (SIC 3484).

- Munition and missile launching systems: large and medium caliber cannons, howitzers, mortars, automatic cannons on airplanes and helicopters, and missile launchers (SIC 3489).

Our study considered only conventional systems. We did not examine nuclear munitions or their strategic delivery vehicles (e.g., intercontinental ballistic missiles). These specialized systems are subject to unique regulatory requirements and internaonal which intrues beyond the scope of this limited industry study.

### General

Armaments are essential in war. While there is limited commercial production for small arms and excavating explosives, the military is the predominant customer, with a market share ranging between eighty and ninety-eight percent. For the most part, armament products have no direct commercial counterparts. The government, therefore, has had to take extraordinary measures to assure the nation maintains capability in peacetime to manufacture armaments in wartime.

The five categories noted above fall into three major product groupings: ammunition, gun systems, and missiles and precision guided munitions. In addition to different product lines, each grouping correlates closely to a different plant ownership structure--with government ownership dominating the ammunition industry, a mix of commercial and government ownership taking place in the gun systems grouping, and commercial ownership dominating the missile and precision guided munitions grouping. Thus, the manufacturing of armaments involves both public and private sectors, linked together in a complex relationship.

Viewing the armaments industry from these two perspectives, major product groupings and ownership structures, provides a comprehensive picture of the industry.

## Product Groupings

### Ammunition

The ammunition group incorporates a broad array of products including projectiles, bombs, mortars, grenades, pyrotechnics, small caliber ammunition, and land mines. Products in this sector are relatively unsophisticated and move to the target without guidance after firing. Ammunition is normally produced on high volume manufacturing lines, even though most current orders are small in size. These items contain some form of energetic material (high explosive, incendiary, and/or propellant) which clearly differentiates these products from other defense sectors. Since 1985, the Army has served as the Department of Defense's (DoD) Single Manager for Conventional Ammunition (SMCA), a position which requires the Army to be the single buyer of ammunition for all services.

### Gun Systems

The gun systems group consists of the guns and recoil mechanisms needed to propel ammunition to targets. The group has three sectors: small, medium, and large caliber guns. Small caliber weapons consist of guns firing projectiles 20mm and smaller and includes many common items such as rifles, pistols, and machine guns. Medium caliber weapons fire projectiles ranging in size from 20mm to 40mm. The most widespread systems are automatic cannons found on ships, helicopters, airplanes, and infantry fighting vehicles. There is a dramatic step-up in lethality as weapons move from the small to the medium caliber range, with many medium caliber systems able to target armored vehicles. The large caliber sector consists of weapons 40mm and larger. Standard large caliber weapons include howitzers, mortars, tank cannons, and naval guns. While small and medium caliber guns fire primarily in the direct fire mode, there is a mix of direct and indirect fire systems in the large caliber sector. Each service manages its own weapons programs, although joint programs take place if there is a common requirement (e.g., next generation rifle).

### Missiles and Precision Guided Munitions

Even though they usually contain propellants and explosives like ammunition, we grouped missiles (including their launching systems) and precision guided munitions (PGMs) separately to highlight their higher levels of sophistication and the different management philosophies governing their development and production. Compared to ammunition, missiles and PGMs are high dollar items (routinely exceeding $10,000 per round and reaching as high as $1.3 million for a Tomahawk cruise missile). This group contains many of the high technology systems made famous during DESERT STORM: Harpoon cruise missile, Patriot, Hellfire, and smart bombs. We also include in this sector less sophisticated missiles and rockets such as the Army's Multiple Launch Rocket System and AT-4 anti-armor missile, even though they do not include any in-flight guidance capability. Naval torpedoes and sea mines fit into this grouping because of their cost and sophisticated seekers and sensors. Each service manages its own missile and PGM programs, often employing a Project Manager to oversee system development and production.

## Ownership Structure

### Government-Owned/Government-Operated (GOGO) Facilities

The government owns and operates several major ammunition and gun system production facilities. They are large industrial complexes, sprawling over many acres and employing a thousand or more people. Six GOGO facilities came under the purview of this study: Watervliet Arsenal, Rock Island Arsenal, and the Naval Ordnance Station Louisville (all involved in the production or maintenance of gun components such as cannon barrels and recoil mechanisms); and Pine Bluff Arsenal, Crane Army Ammunition Activity, and McAlester Army Ammunition Plant (all involved in ammunition production).

GOGO gun producers have a mix of old and modern facilities. During the 1980s, DoD invested over $500 million in new buildings and sophisticated manufacturing equipment. This portion of the GOGO base is relatively healthy in terms of capability. With the exception of some limited modernization, the three GOGO ammunition producers depend primarily on World War II era infrastructure and production systems.

While GOGO facilities face declining workloads, DoD currently intends to keep them all open. They have staying power in this period of base closures because of the critical and unique production capabilities which they provide to the nation's armaments industry. For example, Pine Bluff Arsenal is the sole producer for most smoke ammunition and has the only fill and assembly line for white phosphorous illumination ammunition. Watervliet Arsenal is the primary thick-walled, large caliber cannon manufacturer in the United States. Watervliet demonstrated its unique metal fabrication capabilities during DESERT STORM when it reshaped an eight inch gun barrel into the now famous Bunker Buster--the bomb credited with destroying deep and highly fortified Iraqi command bunkers.

### Government-Owned/Contractor-Operated (GOCO) Facilities

GOCO plants produce much of DoD's ammunition. Although some plants have multiple missions, plants normally focus on one of four major industrial processes: metal parts production, propellant and explosives production, assembling and loading of components and end items, or small arms ammunition manufacturing. Private companies operate the plants and provide the workforce for a negotiated annual fee. Operating contractors range from major defense companies such as Martin Marietta Corporation and Thiokol Corporation, to smaller companies such as Day and Zimmerman who specialize in managing GOCO plants.

The GOCO plant complex consists of twenty-six World War II and Korean War vintage plants and one plant built in the 1980s (Mississippi Army Ammunition Plant). Although most production lines have been idle since the end of the Vietnam War, the U.S. Army retained the excess capacity to provide a ready mobilization capability in case of war with the Soviet Union. In light of the changed strategic environment, the fate of this obsolete and excess production capacity is one of the key issues facing the armaments industry today.

Recent cuts in ammunition procurement have hit this sector hard. Of the fourteen plants active in 1990, four have already ceased production. By 1995, only six are slated to remain active and that number appears optimistic. The survivors provide a critical and unique

capability. Radford and Holston Army Ammunition Plants, for example, are important assets because they provide most of the military's propellant and explosives needs. Lake City Army Ammunition Plant also fills a critical niche as the sole bulk supplier for many types of small arms ammunition.

**Contractor-Owned/Contractor-Operated (COCO) Facilities**

The armaments industry has several prime contractors supported by an array of specialized parts suppliers. Production capabilities range from small 1940s era plants making naval flares to large automated facilities assembling the Army's Multiple Launch Rocket System (MLRS). Since COCO facilities usually produce sophisticated missiles and precision guided munitions, the most modern plants and processes are found in this sector. There are also many COCO plants operating in World War II era buildings and still using manual intensive production methods.

Below the prime contractors are many subsystem and component specialists who also serve as suppliers to government-owned facilities. These companies supply the fuses, seekers, altimeters, navigation systems, power sources, and other specialized components vital to the final product. The Tomahawk cruise missile program, for example, has thirty-two subcontractors working under the prime contractor McDonnell Douglas Corporation. While we were unable to assess the health of the subcontractors and their subtier suppliers, every place we visited indicated the situation was deteriorating. The number of potential suppliers was declining and in many cases lead times were increasing.

**Concentration**

Because of the diverse array of armament products and the intricate nature of the combined government and commercial-owned infrastructure, we were unable to quantify by sales volume the level of concentration in this industry. There are some subjective assessments, however, that can be made, both in terms of a particular product grouping and the industry as a whole.

The government-owned complex plays the dominant role in the ammunition group, with five commercial firms--Allliant Tech Systems, Olin Ordnance, Martin Marietta, Aerojet, and Chamberlain Manufacturing--competing for the major programs contracted to the private sector. The GOCO operating contractors, recently given more freedom to compete directly for DoD and commercial contracts, are also becoming more aggressive competitors. This environment provides a highly competitive field seeking a share of DoD's shrinking annual ammunition procurement budget, which should remain well under $1 billion for the foreseeable future.

Each of the three segments of the gun systems group--small, medium, and large caliber--draws on a different set of suppliers. The small arms sector consists of nine producers, with only three dependent on DoD small arms buys for survival. The others, led by Beretta, successfully compete in the commercial fire arms market or have other DoD/foreign contracts on which to survive. The level of concentration by companies changes periodically as this highly competitive industry segment wins and loses individual contracts. In the large caliber group, most suppliers monopolize their particular product line. Two GOGO facilities--

Watervliet Arsenal and the Naval Ordnance Station Louisville--control the large caliber gun tube and naval gun system markets. The FMC Corporation has produced a number a gun systems for the Navy and has urged the government to close its Louisville so that FMS can capture the diminishing naval gun market. Rock Island Arsenal dominates the market for Army towed howitzer carriages and recoil mechanisms. Medium caliber guns are largely manufactured by COCOs with several companies having this capability. Thus, concentration in the gun systems area ranges from the relatively diversified and competitive small arms sector to a series of near monopolies which control much of the large caliber markets.

Although most major defense contractors participate in some element of the missile and PGM industry, this remains a relatively concentrated market segment, dominated by approximately six companies. Some of the major players and a representative sample of their products include: Martin Marietta (precision guidance systems), Northrop (Tri-Service Standoff Attack Missile), McDonnell Douglas (Harpoon and Tomahawk), Raytheon (Patriot), and Hughes Aerospace (tactical missiles). Most companies, however, specialize in a particular segment of the market, thereby reducing the actual level of competition. The missile and PGM industry appears on the verge of a significant shakeout due to declining DoD procurements. In the last two years alone, there have been three major mergers involving missile manufacturers, and more are likely. This will likely result in a few bigger companies controlling much larger shares of a smaller missile market.

Overall, armaments is a highly concentrated industry with a relatively stable population of major companies and government-owned plants capturing most of the market. Factors contributing to the high concentration levels seen in some segments of the armaments industry include: (1) monopsonistic condition of the market; (2) high entry barriers with few related opportunities in the commercial market; and (3) restrictive buys limited by DoD to officially designated mobilization producers. Thus, this industry inherently moves to a marketplace controlled by few suppliers. The declining defense budget will likely accelerate that process.

## Market Structure and Barriers to Entry

The armaments industry is almost entirely oriented on the defense market. While there is commercial production for small arms and engineering demolition materials, the military is the predominant customer, and in most cases the only customer. For most items, there are no direct commercial counterparts. In addition to one buyer, there are few sellers in many segments of the market. A slew of entry barriers has made armaments an unattractive business for most companies. These include traditional barriers such as environmental compliance and liability, stringent safety and security regulations, and high capital costs. Furthermore, the market is subject to wide swings in demand due to the characteristic volatility in government armament procurements and shifting military postures between peace and war. Thus, any company entering the business risks significant periods of underutilized plant capacity, increasing overhead costs, and declining profits.

Because of steady reductions in the DoD procurement budget over the last seven years, low demand for armaments stands as the most powerful barrier confronting any company trying to enter the market. Established armaments companies are consolidating to capture greater shares of a diminishing market. As long as this trend continues, any venture

into the armaments industry by a new company would be particularly risky.

## CONDUCT

### Impact of Government Policies and Regulations

Because the federal government has a monopsony relationship with the armaments industry, the industry has little choice but to respond to government policies and regulations. Armaments, like most defense sectors, operates under the heavy influence of government regulations and oversight. The overabundance of regulatory requirements serves as a disincentive for firms participating in the domestic armaments market and as a significant barrier to international defense cooperation.

The policy having the greatest impact on the armaments industry today is an old one--a Cold War policy to build and maintain a large mobilization and surge capacity to ensure an adequate wartime supply of critical armaments. With the end of the Cold War, the armaments industry is saddled with massive overcapacity, much of it geared to high volume production in a time of low volume needs. Our estimate is that the government-owned ammunition complex is operating at less than five percent of available capacity. In the GOGO gun complex, rates are higher but they certainly do not exceed twenty-five percent of capacity. The armaments industry of the 1990s faces the difficult and costly task of purging this excess production capacity.

### Government and Industry Relationship

Prior to the 1930s, the military depended on government arsenals for most armament products. Since then, there has been a gradual shift of work from the public to the private sector, although government-owned plants and equipment remain a significant element of the armament industrial base. The military and private industry have developed a strong partnership which has ensured an adequate flow of armaments to meet defense needs and kept the U.S. at the forefront of armaments technology.

The diverse and complex degree of joint government and commercial involvement is evident throughout the production base. For example, many COCO ammunition producers rely on government equipment provided to them at no cost. Even in the missile sector, which traditionally contracts full system development and production to a private company, the prime contractor is often dependent on GOCO and GOGO ammunition plants for certain components. We observed this situation at Loral Vought's MLRS production line which required submunitions produced by Lone Star Army Ammunition Plant (a GOCO). This type of relationship appears to be the industry norm.

While we characterize the government and industry relationship as good, we did note a growing problem of government-private industry competition. Everybody is trying to survive the industry shakeout--government facilities and commercial companies alike. This has led to fierce competition for work, often competing GOGO, GOCO, and COCO operations as a means to rationalize the armaments industrial base, but the competition has to be fair. Many commercial companies expressed concerns to our group that government-owned facilities benefitted unfairly from hidden government subsidies, particularly in the way government-

owned facilities allocate overhead costs and depreciate capital equipment. Competition, if allowed to go too far, has the potential to sour the positive government-commercial relationship which has been one of the strengths of the armaments sector.

## Price Setting Procedures

A monopsonistic situation exists in the armaments industry with DoD acting as the single buyer in most areas. This is an industry composed of several major competitors and many subcontractor and subtier vendors. To survive in the rapidly declining market, companies must compete aggressively to provide the lowest cost to DoD on each order. In some cases, suppliers have offered bids which barely cover fixed costs, let alone provide any return for overhead costs. For those companies dependent on defense sales, this is a battle to the death. There is little opportunity to transition to commercial markets because of the unique defense nature of most facilities and equipment. While the industry shakeout continues, DoD will likely obtain some armament commodities from the commercial sector at relatively low prices, notwithstanding the lower volumes. In other cases, however, smaller production buys will inflate costs. This is particularly true in the high sophistication end of the market.

The U.S. Army Armament, Munitions and Chemical Command (AMCCOM), the Army's operating agent under the SMCA concept, recently introduced "best value" contracting to give proven suppliers a leg up in competitive ammunition component procurements. This concept incorporates past performance into contract awarding criteria, in addition to cost. Thus, the low cost supplier is not always the contract winner. While the government pays higher costs in the short run, it stands to gain in the long run if quality suppliers remain part of the defense industrial base.

## Status of Research and Development and Capital Expenditures

As the sole buyer in the industry, DoD picks up the tab for most capital expenditures and research and development (R&D) programs taking place in the armaments industry. During our visits, we witnessed little in the way of new capital expenditures, although some programs funded in the 1980s are having a positive effect on the industry. For example, Watervliet Arsenal completed a $40 million investment in one of the largest Flexible Manufacturing Systems in the United States. The eleven machine system has the capability to perform work which once required forty machines, while reducing labor costs and improving reiiability and product consistency. This type of major capital expenditure, rare in the past, will likely be nonexistent during the 1990s.

Two main forces are impacting armaments R&D. First, the defense budget draw down is resulting in less total opportunity for armaments R&D. Second, there is the new administration's policy to encourage defense R&D and associated prototyping of high potential systems without production commitments. Thus, on the one hand, overall armaments funding, including that for R&D, is going down; while on the other hand, administration encouragement of R&D is going up. The future for armaments R&D is, therefore, smaller funding but a greater relatively priority and total budget percentage within the overall out-year armaments program.

DoD funnels much of its R&D money to industry through large, government-owned laboratory systems operating within all four services. Government laboratories conduct independent in-house armaments R&D and also work closely with the private sector in monitor or co-performer roles. The armaments industry conducts most R&D in conjunction with specific program development and, to a lesser degree, in an independent R&D mode. Both government and commercial processes are necessary for the total armaments R&D capability --one cannot work without the other.

## PERFORMANCE

### Trends in Sales and Shipments

U.S. armaments sales have been on a decline for several years. The down trend in sales is not just a U.S. phenomenon--it is taking place on a global basis (with the exception of a few specific countries). The military's ammunition account illustrates the magnitude of DoD's armament procurement reductions. The fiscal year 1993 ammunition production budget is approximately $700 million, down significantly from the $2.0 to $3.0 billion budgets of the mid-1980s. This down trend is apparent in most armament sectors.

A review of specific DoD budget procurement line items provides some insight into DoD's armament strategy and future market trends. The services' procurement plans reflect a general "neck down" strategy in terms of decreasing variety of weapons as well as procurement quantities. Conversely, DoD is requesting significant modernization funding to upgrade existing stockpiles. Few new program starts will take place and most of those currently in production will complete production runs by mid-1990s.

Another factor having a major impact on sales is the military's continuing shift from "dumb" ammunition to more effective missiles and precision guided munitions. A single laser guided bomb or Tomahawk cruise missile now handles missions that once required thousands of bombs. More effective munitions allow the services to buy much smaller quantities to achieve the desired result on the battlefield. This trend to smarter munitions, underway for over two decades, has siphoned work from the government-owned ammunition sector and shifted it to the private sector.

Even in declining markets, there are often niches of growth, and that is true in armaments. One area that will likely see increased funding is demilitarization of ammunition. The military's backlog of unserviceable and obsolete munitions now exceeds 350,000 short tons, or the equivalent of 7,280 railroad cars. Even with annual funding for demilitarization recently raised to $35 million, the backlog continues to grow. Since munitions in the demilitarization account raise unique safety and environmental concerns, this area will likely receive higher funding in future years. Several commercial companies and GOCO contractors have targeted this as an area for potential new business. An even larger market for demilitarization exists within the former Warsaw Pact and is being actively pursued by firms such as Alliant Tech.

### Trends in Productivity

While there are some highly publicized productivity initiatives in the armaments

industry (e.g. Watervliet's $40 million Flexible Manufacturing Systems), productivity in this industry appears to lag other industrial sectors. With the exception of a few modern facilities, this industry is characterized by antiquated processes, low volume production on high volume lines, manual intensive procedures, and outmoded infrastructure. It is testimony to the industry in general that it performs so well in such a difficult environment.

Stagnant productivity is not entirely due to lack of investment--the toughest job appears to be determining where to invest. During the 1970s and 1980s, DoD spent several billion dollars updating the ammunition production base. The U.S. Army poured over $700 million into building Mississippi Army Ammunition Plant, the only new ammunition plant constructed since the 1950s. This highly automated plant was designed to produce 120,000 M483 artillery projectiles (155mm improved conventional munitions) per month. In 1990 the Army closed the plant--the requirement for M483 rounds had dried-up, and it was not economical to convert to other products. The huge investment contributed nothing to the productivity of the industry. There are many similar examples.

The productivity story is not all bad. Loral Vought's Multiple Launch Rocket System (MLRS) is a success story. During our visit to the MLRS plant in Camden, Arkansas, we saw a modern and highly productive 217,000 square foot manufacturing facility. The company has been producing MLRS since 1982 and benefitted significantly from program stability and multi-year contracts. These factors allowed the company to invest in modern facilities and continually focus on productivity enhancements (e.g., robots). On a smaller scale, we were also impressed with the productivity of Hitech, a small company working on high performance warheads, demolition charges, and pyrotechnics. While they only employed forty-five to sixty people, the array of products the company produced was amazing. Their flexible production facilities and processes allow them to provide customers rapid response times and relatively low prices on small volume orders.

## Trends in Profitability

This is a difficult industry in which to assess profitability. Furthermore, profitability does not provide a completely accurate indication of the armament industry's health because of the large role government-owned facilities play in the business. The long-term trend, however, appears clear--profitability is on the decline. Except for a brief respite during the Reagan buildup, this trend dates back several years. The compounding impact of fewer and smaller procurements coupled with an increasingly competitive environment makes it a safe prediction to say that most armament suppliers and their subcontractors will see dramatically lower profits for the foreseeable future.

## International Trade and Competition

The U.S. is the leading force in the world's armaments market, although U.S. exports represent only about ten percent of the nation's total arms production. The Middle East, Western Europe, and the Pacific Rim are the principal customers for U.S. armament sales. Market preeminence stems from a comprehensive array of advanced weapon systems, many successfully demonstrated in combat. U.S. armament systems generally represent a first choice for many foreign countries; however, lower cost competitors and politically imposed restrictions on the transfer of armaments and advanced technologies keep U.S. companies

from capturing a larger share of international arms markets.

Reduction in armament sales is not just a U.S. problem; it is global trend. During our overseas travel, we found a European armaments industry which had already taken major strides in terms of adjusting to the overall reduction in demand. As America's principal competitors in international arms markets, it is instructive to look at the specific actions Europeans have taken in this regard.

First, each of the three countries we visited--Germany, France, and Great Britain--had a clear industrial policy to deal with the defense draw down and increased international interdependence. Great Britain, for example, has moved toward a policy of selling off government-owned facilities. Royal Ordnance, now a subsidiary of British Aerospace, underwent a restructuring and downsizing following its privatization and has emerged as even a more powerful competitor. France has taken the opposite approach. France maintains strong government involvement in its armaments industries. While France lets Giat and Thompson-CSF operate as independent companies, they remain fully government-owned.

Second, because national defense markets are too small to support solely domestic industries, European defense firms actively pursue collaborative arrangements and seek to export large quantities of armaments. Export sales are necessary to support economic production runs and to help fund the next generation of weapons. While the U.S. exports about ten percent of its armaments output, European nations often send over fifty percent of new production to international markets. To gain further economies of scale, most major weapon development and production programs are done on a multi-national basis, with participating companies and nations receiving production workshares based on their financial contributions to the overall project. These multi-national programs effectively block most forms of external competition. There are fewer collaborative programs with the U.S. because of U.S. government restrictions on armaments proliferation and complex cost accounting rules.

Third, European defense industries are ahead of the U.S. in downsizing capacity and adopting advanced manufacturing techniques. In adjusting to the post-Cold War era, the Europeans have one major advantage--they did not maintain a huge production base to support a possible global war with the Soviet Union. Since World War II, they have largely relied on war reserves and potential capacity available in the U.S. to meet wartime requirements. Thus, their degree of downsizing is small compared to the overcapacity problems the U.S. now confronts. To the European's credit, governments and armament companies have not been timid about eliminating excess capacity and consolidating redundant organizations. Because of their smaller production sales, European defense companies have developed flexible production facilities and applied advanced manufacturing processes to squeeze maximum capability out of limited resources.

Finally, the European armaments industry is trying to gain a larger toehold in America. European companies and military defense representatives we visited made it clear that they consider the U.S. armaments market closed to outsiders. Direct procurements are only available to U.S. based companies. Their strategy to penetrate the world's largest arms market is through joint ventures and acquisition of U.S. defense companies. We saw firsthand evidence of some early successes during our visit to Hitech (a producer of advanced explosive warheads) in Camden, Arkansas. Hitech is a subsidiary of Conventional Munitions

Systems Inc. (CMS), a Florida based company, which is in turn a wholly-owned subsidiary of Germany's Deutsche Aerospace. In addition to carving out a niche for conventional warheads, CMS recently won a large contract to clear unexploded ordnance from the U.S. assigned zone in Kuwait. Another prominent example of foreign ownership of a U.S. based company is Giat's FN Corporation, the current producer of the M16A2 rifle. There is likely to be a steady increase in companies operating in the U.S. defense market with formal links back to the European armaments industry.

In addition to the radical restructuring and increasing export orientation of European armaments companies, there is further turbulence in international markets caused by the breakup of the Soviet Union. Many former Soviet states have large surpluses of weapons and ammunition, and most are willing to make sales at bargain prices. Furthermore, countries such as Brazil, the People's Republic of China, South Africa, and Israel, trying to attain greater self-sufficiency in defense industries, are capable of producing large quantities of low and medium technology weapons for export. Thus, there is an abundance of countries and companies who want to sell armaments in a market with shrinking demand.

Many U.S. armament companies are turning to international markets to expand their customer base and revenues. Those companies opting for this strategy will meet tough resistance. They will encounter a global arms market characterized by: reduced defense purchases, excess production capacity, shrinking markets, and streamlined foreign competitors fighting to expand market share. Additionally, U.S. firms are likely to face increasingly stiff export controls from the federal government because of a rising concern over arms proliferation. In this environment, U.S. companies will have a difficult time just maintaining their market share, let alone expanding it.

## OUTLOOK

### Ability of Industry to Meet National Security Requirements

#### National Military Strategy Drives Requirements

The nation's National Military Strategy provides the framework in which military planners determine peacetime and wartime armament requirements. For the past forty years, the threat posed by the Soviet Union dominated U.S. military strategy. Because the Soviet military threat was so large, DoD constantly faced a situation where requirements for armaments dwarfed the production base's resupply capability. The armaments community responded by building large reserve stockpiles and maintaining a mobilization base which provided some hope that the U.S. could fulfill potential requirements in a protracted global war.

With the collapse of the Soviet Union in 1990, U.S. military strategy shifted focus from global war with the Soviet empire to regional conflicts where short, decisive battles determine winner and loser. In these short and violent conflicts, there will be no time to gear up the manufacturing base. U.S. forces will rely on existing stocks for the majority of their support. Large armament stocks built up during the Cold War provide a "nest egg" on which to base contingency plans. DESERT STORM is typical of regional conflicts which the U.S. is likely to face in the future. While industry was able to respond rapidly to war requirements with

commercially produced items (e.g., meals-ready-to-eat, combat boots, etc.), Patriot PAC II and the Army Tactical Missile System were the only major weapon systems where a production surge contributed to the war effort. This occurred only because long-lead items for later buys had already been delivered to manufacturing sites. The Army did not have to reactivate any of its inactive ammunition plant base to support the war.

The current DoD strategy in this more benign world is clear: coast for the remainder of the decade on the huge armaments inventories assembled during the Cold War. This strategy is one of the reasons the armaments industry has been hit so hard in the military draw down (e.g., ammunition procurement is only one third of mid-1980 levels). Most production work in the armaments sector will center on providing sufficient training ordnance and gun spares to maintain readiness and building initial inventories of the newer and more modern weapon systems and munitions.

## Assessment of Peacetime, Surge, and Reconstitution Capabilities

As the new structures and missions for post-Cold War era military forces take shape, DoD needs to ensure that the U.S. maintains an adequate combination of stockpiled armament systems and existing industrial capacity to accomplish the following objectives:

- Provide high quality armaments to meet peacetime and foreign military sales requirements.
- Provide a surge production capability during any warning period to minimize draw down of war reserves.
- Recover quickly from a draw down of war reserves after conflict to minimize the period of U.S. vulnerability.
- Retain idle capacity, where economically feasible, which is unique and difficult to regenerate so that the nation can reconstitute its force structure in a reasonable time frame.

Overall, we believe the armaments industry will have few problems meeting our national security requirements for the remainder of the decade. Industry is more than capable of producing the types and quantities of armaments projected in outyear budgets and longer term planning documents. Although production rates are significantly below Cold War era rates and the industrial base will shrink, some production is likely to continue in most major product areas. This gives the armaments industry a major advantage over other unique defense industries such as submarines and tanks where significant production gaps may occur later in the decade. Furthermore, DoD has identified some government facilities as critical national assets and appears committed to keeping them open. These include (list is not all inclusive) such important one-of-a-kind facilities as Radford Army Ammunition Plant (propellants), Holston Army Ammunition Plant (explosives), Lake City Army Ammunition Plant (small arms ammunition), and Watervliet and Rock Island Arsenals (cannon tubes and gun recoil systems and mounts).

While the inactive production base provides little value in terms of meeting peacetime

or regional contingency requirements, it does have extraordinary value in terms of reconstituting the armaments production base later in the event a new superpower adversary emerges. These plants are situated on land well suited for industrial purposes and difficult to replace once lost to the civilian sector. Ready access to the land and the plant infrastructure will significantly reduce the response time required to regenerate high volume production should the need arise. DoD's strategy of retaining some inactive facilities, while spending little to maintain them, provides the nation an excellent, low cost "insurance policy."

The one area of risk appears to be in the ability to surge armaments production before and after conflicts. Declining procurements will result in the end of a warm production base for much of the armaments industry. For example, in the ammunition sector, DoD will have no active producers for such common items as 30mm lightweight and GAU-8 ammunition for the Apache and A-10, 105mm tank ammunition, scatterable mines (ADAM, RAAM, and Volcano), and nitroguanidine used in triple base propellants. As more production lines go idle (a fact of life given projected armament budgets), response times will increase and commercial producers will exit the market. By most accounts, it takes over twelve months to regenerate production of ammunition items once a line ceases active production. In the case of the more sophisticated missiles and precision guided munitions, it will take upwards of eighteen to twenty-four months to surge production of most items, and another twelve to eighteen months before there is a sizeable increase in delivery rates.

The downsizing process puts a premium on DoD's ability to accurately forecast armaments requirements in future conflicts. If the requirements generation process is right and DoD has or buys sufficient stockpiles to meet calculated requirements, surge is not an important issue. However, if projections are wrong or budget constraints prevent DoD from meeting stockpile targets, the nation stands a high risk of running out of certain key armament items during future conflicts.

The missile and precision guided munitions product grouping is the area which merits the closest attention in surge planning. This is the sector dominated by commercial forces, and it will quickly resize to balance supply and demand. It is also the product area where the nation will most likely need a surge capacity because there are not large inventories of many of its expensive and advanced weapon systems. Military planners should consider stocking long-lead components to provide at least a limited surge capacity for critical war stopper items. The ability to surge Patriot PAC II and the Army Tactical Missile System during DESERT STORM demonstrated the potential value of such a policy.

## Technological Opportunities

### Near-term Outlook (1994 - 2000)

There are no significant technologies that will dramatically affect the armaments industry in the near-term. The technology focus will be on improving performance of existing systems and resolving specific battlefield deficiencies, particularly those noted during DESERT STORM (e.g., sea mine countermeasures). The general focus will be on extending the range of munitions, increasing warhead lethality, improving hit probabilities, and making lighter and more transportable armament systems. Based on our observations, one of DoD's priority technology areas is the destruction of enemy armored vehicles. During our visits, we

witnessed multiple programs directed at killing tanks, with each service working on improved ordnance and warheads. There appeared to be considerable redundant effort across the services in this area.

Technology programs in gun systems focus on upgrades to existing systems. Near-term "new weapons" are primarily updated versions of old designs and will likely be around for another twenty years or longer. Because new gun systems will remain similar to current weapons, the industrial base should not have to make large investments in new industrial processes or equipment just to produce a new gun system This observation is also applicable to the ammunition and missiles and PGMs product groupings

One area which could stand a major infusion of new technology is the demilitarization of ammunition and missiles. As stated earlier, the size of DoD's inventory of obsolete and excess munitions waiting destruction now tops 350,000 short tons and is growing daily. The magnitude of the problem is likely to escalate further as DoD faces the possible closing of the few remaining open burning/open detonation sites due to tougher environmental standards. The alternative method, destruction by incineration, takes more time and is very expensive (about $1,000 per short ton). A more cost effective destruction process, able to destroy high volumes of many ordnance types and still operate in compliance with environmental regulations, would represent a major technological breakthrough.

**Long-term Outlook (2000 - 2010)**

In the long-term, advanced propulsion technology and advanced materials technology are likely to have the most impact on the armaments industry.

In the area of advanced propulsion, electro-thermal (ET) and electro-magnetic (EM) gun technologies provide a potential leap-ahead capability. ET technology involves the conversion of electrical energy into projectile kinetic energy via a working fluid. The process is less efficient than EM technology, making EM the current front runner of the two competing technologies. Even with its high priority in technical base R&D funding, development of an EM gun is not projected until the year 2007 at the earliest. One of the biggest technology barriers involves reducing the size of EM power supplies to make them compatible with vehicle and ship applications. EM guns provide a leap ahead capability in such key battlefield parameters as range, accuracy, rate of fire, and lethality, while significantly reducing the overall logistics burden. These technologies operate under the purview of the DoD Joint Electric Gun Program and are likely to remain high priority technology areas for the remainder of the decade.

The other technology area key to armaments is advanced materials technology. While there is a constant push to increase performance of weapon systems, there is also countervailing pressure to make weapons lighter, smaller, and more affordable. Advanced materials, such as composites and ceramics, have the potential to address these concerns. With further advances in this technology and related manufacturing processes, these new materials should have adequate strength and durability to make them integral elements of next generation weapon systems.

# STRATEGY FOR INDUSTRY SURVIVAL

## Industry's Response to Changing Market

### Government-Owned Production Base

The government-owned sector (includes GOGO and GOCO facilities) has been especially hard hit in the draw down. This is the sector with the largest overcapacity problems, carried over from the Cold War. Plant closures are the order of the day. The workforce at government-owned ammunition plants will drop to around 7,000 in 1997 from over 21,000 employed in 1991 (already a greatly reduced number from mid-1980s manning levels). AMCCOM has orchestrated this downsizing based on a strategy called AMMO-FAST 21. It consolidates capabilities and resources into Group Technology Centers, plants designated to remain repositories for key production technologies and processes. By consolidating to this core plant base, the government-owned base gains greater efficiency and limits the rise of overhead rates.

Also included in AMMO-FAST 21 are new strategies to increase plant utilization, particularly at the plants going to an inactive status. Facility contracting is the approach currently receiving the most attention in political and military circles. By entering into a facilities contract with a GOCO contractor, AMCCOM (the Army's ammunition base manager) gives the operating contractor freedom to seek work from DoD, other government agencies, and commercial sources. The work does not have to be armaments related. The contractor is also free to lease facilities to other firms with the contractor serving in a role similar to a master leaseholder. Under this new approach, the contractor has a chance to transform an inactive plant (with minimal staffing and profit potential) to a much higher level of activity with all the benefits and risks inherent in the free-market system. The government's principal objectives are two fold: reduced cost and increased readiness. As the contractor brings work into the plant, he assumes the maintenance and operational burden for all buildings and equipment being used, freeing the government from bearing these costs. On the readiness side, increased activity (larger workforce and more active facilities) shortens the plant's response time to regenerate an ammunition production capability.

Congress has embraced facility contracting because it offers hope for increased employment at otherwise inactive plants. In 1992, Congress enacted the Armaments Retooling and Manufacturing Support (ARMS) Act (Public Law 102-484) to promote facility contracting at government-owned ammunition plants. The ARMS initiative includes a $200 million appropriation to provide incentives and assistance to companies interested in moving to an ammunition plant. The ARMS Act assigned the Secretary of the Army overall responsibility for overseeing ARMS initiatives and preparing implementing instructions. The Army's implementing policies should be published during 1993. The impact of this program bears watching because of the dramatic effect it could have on the government-owned production base, and because it stands at the forefront of government efforts to promote dual use of defense manufacturing facilities.

### Commercial Production Base

The commercial side of the armaments industrial base does not face the massive

overcapacity problems inherent in the government-owned sector. Because of cost inefficiencies, the free-market system does not let private companies hang onto idle plants and equipment. Thus, in this sector, there is a powerful force at work that automatically reshapes the industry to match demand. Production capacity will continue to decline for the foreseeable future as a result of consolidations or exodus from the armaments industry. Projected low-level procurements and upgrades to existing systems, however, should be sufficient to sustain an adequately sized commercial production base.

The consolidation of the commercial armaments sector is likely to result in one or two dominant participants in each segment of the market, with others focusing on small niche areas. In the last two years, there have been three major mergers in the missile sector alone. Martin Marietta bought out the aerospace division of General Electric, Hughes Aerospace (GM) bought the missile division of General Dynamics, and Loral Corporation bought LTV's missile division. The combination of Hughes and General Dynamics creates a combined missile company which matches the annual sales volume of Raytheon, the industry's previous "top dog." According to a senior Hughes official, "Hughes Missile Systems Company has the opportunity to become the number one producer of tactical missiles if the consolidation is completed successfully over the next few years." The same pressure to consolidate is also taking place in Europe. For example, British Aerospace officials whom we visited indicated that their company was actively discussing the possibility of merging with Matra, a French missile maker. Most missile manufacturers appear to have come to the same conclusion: major companies cannot survive in the shrinking armaments market without establishing a critical mass and dominating a segment of the market.

While mergers and acquisitions are likely to be the principal strategies used by armaments companies to adjust to the changing marketplace, many companies are also seeking to diversify internally into other business areas. Most primes and major contractors are not solely dependent on the health of the armaments market for survival. For example, Olin Corporation, one of three major commercial vendors for medium and large caliber ammunition, generates only one third of its income from ammunition sales. The remainder comes from commercial chemicals and metals processing businesses--production processes closely related to those found in ammunition manufacturing. Some prime contractors, however, are not nearly as diversified as Olin. Another ammunition producer, Alliant Tech Systems (ammunition division spun off by Honeywell) is an extreme example in the other direction. Alliant Tech is totally dependent on its armaments related business. Alliant Tech's strategy is to continue concentrating on defense business while broadening the company's range of capabilities, with ammunition demilitarization and maintenance areas under consideration.

Major companies in the industry are also looking to collaborate and form strategic alliances to obtain new technologies and spread risk. The alliance structure is likely to increasingly cut across international boundaries.

The area most impacted by the defense draw down are the lower-tier subcontractors who provide many specialized components. They have few opportunities to follow the same survival strategies employed by larger companies. For the most part, their survival hinges on the flow of work generated by the government-owned base or larger commercial contractors. With orders in a decline and higher tier companies more likely to keep work in-house rather

than subcontract, this sector is particularly vulnerable. Many will go out of business; they have no other alternative. Loss of subtier vendors will hardly be noticeable in a peacetime environment, but the depleted vender base is likely to become a major constraint in a surge situation. Foreign suppliers provide one avenue to help alleviate this risk.

## RECOMMENDATIONS FOR GOVERNMENT

Notwithstanding the thoroughness and the apparent rigor of existing U.S. defense planning and requirements generation processes, we believe that the dominant characteristic of the future is its uncertainty. Far more than in previous years, the range of plausible future outcomes and their potential impact on the world environment is remarkably broad. In these uncertain times, DoD's strategy needs to "hedge bets" for the remainder of the decade.

During this time, the U.S. can generally coast on existing capabilities and inventories. This should not be viewed as a passive state of inaction arrived at by default, but as a conscious (if interim) strategy which has to be frequently revisited--at least until the future strategic landscape comes into sharper focus. U.S. actions during this period need to strike an appropriate balance between the following two criteria:

*1. Financial resources will be in short supply for the foreseeable future, and the U.S. needs to take steps to husband them--sometimes even if the resulting actions cannot be sustained in the long term.*

*2. Even more important, the U.S. should try to preserve through the near- and mid-term the maximum flexibility to respond to an uncertain future, again even if unsustainable in the long term.*

We recommend the following interim actions which recognize the realities of DoD budget constraints and provide the armaments industry the necessary flexibility to adapt to an uncertain future:

DOWNSIZE THE GOVERNMENT AND COMMERCIAL PRODUCTION BASE IN VIEW OF SHRINKING REQUIREMENTS. If adequate production capacity exists in the private sector, the corresponding government facilities should be eliminated, and no funding should be allocated for maintaining them in any warm state. However, near-term retention of the real estate is an inexpensive hedge against future uncertainty, as discussed above. This strategy is especially inexpensive in comparison to the disposal/cleanup costs which would otherwise be immediately incurred. Active government facilities should be consolidated into as few locations as possible--current excess capacity in these facilities is a load on overhead costs and in the long run is detrimental to maintaining production capability.

Most government facilities are operating at forty per cent capacity or less. This condition directly increases the unit cost of items produced because of inefficient production lot sizes and increased overhead costs. DoD can no longer afford the luxury of maintaining this excess capacity except in those very few instances where it gives the ability to surge production of some key end items that might be needed in a short notice regional conflict.

Unfortunately, most excess capacity is in the production of older munitions and

systems that are already in the stockpile, not the "preferred" munitions of choice for future battlefield commanders. During the Cold War this excess capacity was justifiable because of mobilization requirements. This has changed with the collapse of the Soviet Union and the prospect that we have years of warning for the emergence of any future global threat. In this light, we believe that initiatives like the AMCCOM plant downsizing under the AMMO-FAST 21 program mentioned earlier are appropriate and timely.

RETAIN CRITICAL PRODUCTION CAPABILITIES. Certain government owned facilities provide critical production capabilities by manufacturing unique items that are not economical for the private sector to produce. These critical production capabilities are those which produce essential armaments and do not exist in private industry or would be prohibitively costly to establish.

One prominent example from our study would be the large caliber gun tube manufacturing capability at Watervliet Arsenal. While currently operating well below capacity, this facility would be unreasonable to create in private industry. Moreover, it has provided a specialized in-house manufacturing capability which permitted the quick deployment of the GBU-28 hard target penetrating bomb.

REVIEW NATIONAL MILITARY REQUIREMENTS AND CAPABILITIES TO REDUCE REDUNDANCY. Numerous opportunities exist to improve the effectiveness and efficiency of DoD armaments development efforts by consolidating--or at least coordinating--work in critical technologies areas. As examples, we saw multiple efforts ongoing to develop anti-armor weapons, especially those employing top attack principles, as well as high-performance fragmentation-type missile warheads.

While redundant technology efforts are important to reduce risks before choosing final solutions, DoD should improve the sharing of technology among developmental teams. In particular, the Under Secretary of Defense for Acquisition and Technology should be directed to force closer cooperation among the services.

EXPLOIT INTERNATIONAL COOPERATION TRENDS. We believe it is a canard to claim that the U.S. must cooperate with friends and allies in the belief that otherwise some particular effort would be unaffordable. More likely, if the effort is genuinely unaffordable, it will also be so if undertaken collectively. After all, even with dramatically reduced budgets, U.S. expenditures will still be roughly an order of magnitude greater than those of our potential European partners--and they continue to find national champions affordable.

The U.S. should, however, recognize the trend toward international cooperation and exploit it as an entry into markets and an intelligence window. It is also an opportunity to sustain U.S. influence abroad, and to ensure that our closest allies--with whom we would expect to operate in future coalitions--remain equipped with modernized armaments.

LET COMPETITION FOR BEST VALUE BE THE BASIS FOR RATIONALIZATION BETWEEN GOVERNMENT AND COMMERCIAL SECTORS. We believe we have seen only the beginning of a bitter and divisive debate on methods to balance competition between government and commercial sector providers. To head off a worsening environment, DoD should move to aggressively set out the ground rules for these competitions, and frame them

in terms of best value to the taxpayer.

It is clear from our discussions (as well as the debate played out on the stage in the 7 April 1993 ICAF Association Symposium on the future U.S. industrial base) that the competition for depot maintenance and other services is already a bitter and highly politicized issue. This is likely to spread as the rationalization process continues on its painful way. While some conflict is unavoidable, we believe it can be tempered by early action to put competition on a footing which will be perceived as fair by all the players.

# INDUSTRY STUDY

# # 6

# COMBAT VEHICLES

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## PARTICIPANTS

### Students

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LTC (P) Walter Ben Grimes, USA

LTC John W. Holly, USA

Ms. Louisa H. McAllister, D/N, GM-15

LTC (P) Michael L. McGee, USA

LTC (P) Sheryl E. Murray, USMC

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LtCol William H. Rohlman, USAF

LtCol Toreaser A. Steele, USAF

LTC (P) Lloyd T. Waterman, USA

CAPT Christopher E. Weaver, USN

LTC (P) Charles W. Weston, USA

LTC (P) Joseph L. Yakovac, USA

### Faculty

Dr. James T. Currie

Col David G. Francis, USAF

COL Michael F. Shisler, USMC

Col Karl F. Whittenberg, USAF

## PLACES VISITED

### Domestic

| | |
|---|---|
| Advanced Research Projects Agency (ARPA) | Arlington, VA |
| AM General Corporation (HMMWV utility vehicle) | South Bend, IN |
| BMY Corporation (tracked vehicles) | York, PA |
| FMC Ground Systems Division (Bradley fighting vehicle) | San Jose, CA |
| General Dynamics Land Systems Division (Abrams tank) | Lima, OH |
| GTE (sub for vehicular antenna masts) | San Jose, CA |
| Oshkosh Truck (medium/heavy trucks) | Oshkosh, WI |
| US Army Tank-Automotive Command (TACOM) | Warren, MI |
| US Army Test and Evaluation Command (TECOM) | Aberdeen, MD |

### International

| | |
|---|---|
| Ford Motor Company, Limited (cars) | London, England |
| Giat (LeClerc tank and tracked vehicles) | Paris, France |
| Industrial Vehicle Company (IVECO) (trucks) | Ulm, Germany |
| Krauss-Maffei (Leopard tank and tracked vehicles) | Munich, Germany |
| MAN (medium/heavy trucks) | Munich, Germany |
| United States Consulate | Stuttgart, Germany |
| Vickers Defence Systems (Challenger tank and tracked vehicles) | New Castle, England |

***Through the development and fielding of technologically advanced weapons and equipment to our fully trained and well-led soldiers, the Army has deterred war, and when necessary, fought and won.***

**Stephen K. Conver**
**Assistant Secretary of the Army**
**(Research, Development and Acquisition)**

## INTRODUCTION

Defense budgets have been declining now for several years. All of the defense industry has felt the impact, and the nature of industry adjustments is becoming apparent. In the combat vehicles industry, in particular, budget reductions both in the United States and internationally, are causing major restructuring and rethinking of roles and strategies.

Combat vehicles are viewed as the backbone of the Department of Defense (DoD) ground warfighting capability. Despite the sophistication of today's aircraft and precision guided munitions, to succeed in battle we must send soldiers and Marines in combat vehicles to take and hold the ground. How we equip these forces, and preserve their position as the best in the world, requires rethinking by the government and the combat vehicles industry alike in the post-cold war era.

To place the industry in context relative to other industries, combat vehicles represent only 2 to 3 percent of DoD's procurement obligation authority. This industry is not likely to receive either the lion's share of attention nor assistance from Congress or the Administration in the near future.

The combat vehicles industry produces some 15 to 20 vehicle types, ranging in size and complexity from the relatively simple heavy equipment transporter (HET) to the main battle tank (MBT), with its sophisticated fire control, armor, command and control, and armament systems. In the United States, relatively few prime contractors produce the various systems. Eight US firms produce the majority of the currently fielded combat vehicles; in descending order of 1992 purchases, these are FMC Ground Systems Division, General Dynamics Land Systems Division, Harsco (BMY Corporation), Oshkosh Truck, LTV Aerospace and Defense (AM General Corporation), General Motors Corporation, Textron (AVCO), and General Electric Corporation. Two of these, FMC and BMY, have formally issued an intent to merge, reducing the field further, and other companies have been less active in this field in the recent past.

The 1993 Combat Vehicles Industry Study Group examined the research, development, upgrade, testing and current strategies for the combat vehicles industry. Combat vehicles are defined as either wheeled or tracked vehicles which assist ground forces in their mission of closing with and destroying the enemy. This definition includes tanks, self-propelled howitzers, infantry and cavalry fighting vehicles, recovery and resupply vehicles,

wheeled armored fighting vehicles, and tactical trucks of all sizes. This industry is divided several ways, as follows:

Categories:

- Contractor operated facilities, whether government owned or contractor owned;

- Government owned, government operated (arsenals and depots). (NOTE: There exists a significant upgrade, overhaul, and modification capability in the depot structure.)

Groupings:

- Armored vehicles with integral armament systems, e.g., M1 Abrams main battle tank, M2/3 Bradley infantry/cavalry fighting vehicles, and the light armored vehicle;

- tactical support vehicles, e.g., High Mobility Multi-Purpose Wheeled Vehicle (HMMWV), Palletized Load System (PLS) and Heavy Equipment Transporter (HET).

Classifications:

The products of this industry fall under the following US Department of Commerce Standard Industrial Classification (SIC) codes within the major industry segment of Transportation Equipment (SIC 37):

- SIC 3711 -- motor vehicles and car bodies;
- SIC 3713 -- truck and bus bodies;
- SIC 3714 -- motor vehicle parts and accessories;
- SIC 3795 -- tanks and tank components.

## INDUSTRY STRUCTURE AND CONDUCT

### STRUCTURE

#### Concentration

The U.S. contractor-owned combat vehicles industry is highly concentrated. The top three prime contractors, General Dynamics, FMC, and BMY (a Harsco subsidiary) developed and produced the majority of all tracked combat vehicles and product improvement programs (PIP) in the 1990s. The fourth largest prime contractor, Oshkosh Truck, has a significant portion of the heavy tactical truck segment of the combat vehicles industry. The August 1992 issue of Government Executive listing of the top 200 federal contractors indicates that these four contractors garner 59 percent of the DoD tank and automotive market share. When their subcontractors are included with these four primes, concentration increases to over 90 percent. Yet when considered in a worldwide perspective, the former Soviet Union produces 60 percent of the world's tanks while the "U.S." contributes only 20 percent.

The government portion of this industry includes five Army and two Marine Corps maintenance depots, and two Army arsenals. They have a combined annual maintenance

and overhaul budget of approximately $630 million. The Army depots are required by law to receive 60 percent of the maintenance and overhaul work **historically performed** by depots. For this industry, this includes upgrade, overhaul and rebuild, but not new manufacture. In addition, they may also compete with private corporations for the remaining 40 percent of the maintenance requirements. In spite of this tremendous potential to obtain most of the Army and Marine Corps maintenance work, the recent significant force reductions have resulted in approximately 25 percent overcapacity in the Army's five depots. The Marine Corps depots are not experiencing this phenomenon.

**Status of Industry Capital and Work Force**

***Industry Capital:*** The equipment used in this industry is a mixture of government and privately owned, in widely varying proportions from company to company. Production equipment reflects a mixture of old and new technology. Within the same plant it is not unusual to find both robotics and manually operated equipment. In the international arena, Vickers prides itself on producing a virtually hand-made tank, employing handwork to accomplish tasks like handfiling and buffing. Domestically, Oshkosh employs robotics to perform the task of plate riveting, yet bolts the chassis manually. The industry is also capable of flexible manufacturing in some of its plants. BMY's highly flexible, defense-oriented manufacturing method enables the company to produce multiple products in the same plant. This allows BMY to achieve its strategy of high mix, low volume production, which it considers its greatest strength.

Heavy investments in the 1980s enabled the U.S. to modernize facilities in its two tank plants, thus providing a total capacity for 120 tanks per month, and to build a light vehicle plant designed solely to produce the HMMWV. The US investment in tank production automation was an appropriate strategy for the large production runs expected at that time. With present decreased demands, covering fixed costs is a problem. Conversely, most European firms use less automation in tank production facilities, allowing much lower break-even quantities, such as 2 to 3 tanks per month. European truck lines are somewhat more automated than U.S. lines.

It is very difficult for firms with traditional American business culture and a largely short-term perspective to fully recognize the long-term benefit of upgrading and modernizing plant equipment with the current uncertain future. Longer term commitment from the U.S. government, such as more maintenance work and incentives for plant investment in the private sector, would encourage appropriate modernization to meet future demand. However, the lack of perceived future demand will likely continue to limit corporate investment.

***Work Force:*** The age, skills and education mixture in the work force is quite varied. For instance, the average plant worker at BMY is 41 years old with an eighth grade reading level. Despite relatively low education levels, many of these workers are highly skilled in their trade. By comparison, the electronics technicians at General Dynamics Land Systems Division were younger and possessed college degrees. Overall, the work force is downsizing and consequently, is aging. Because of the seniority system incorporated into union contracts, younger workers are the first to be laid off. The laid-off workers generally have highly developed skills in areas such as welding, and can relocate relatively easily. Therefore,

they are not likely to be immediately available if the need for their skills recurs. The longer term concern is that as older workers retire, the companies will be left without trained replacements who in previous years would have been coming up through the system. Nevertheless, unions and management generally appear to be working together for the good of employees and the sustained survival of the industry. This may help alleviate these short and long term concerns.

### Market Structure and Barriers to Entry

***Market Structure:*** On the surface, the combat vehicles industry appears to be an oligopoly, especially at the prime contractor level. However, within the United States, the industry actually consists of several monopolies. For example, General Dynamics Land Systems Division is the only producer of tanks; and once FMC's Ground Systems Division and BMY merge, the resultant organization will be the only U.S. producer of light to medium tracked vehicles. At the second tier, the industry is characterized by groups of vendors, oligopolies, who are shared by the prime contractors for uniquely military components. The European structure is quite similar with virtual monopolies in those countries visited by the industry study group: Vickers in the United Kingdom, Giat in France and Krauss-Maffei in Germany.

***Barriers to Entry:*** There are numerous barriers to entry that discourage newcomers into the combat vehicles industry. Primary barriers to entry are the capital intensive investment requirements, high cost of research and development (R&D), high skill requirements, low volume that prevents economies of scale, high risk of failure, and the general instability associated with performing on contracts with the U.S. government. Of course, a major discouragement to entry comes from the decreasing global combat vehicles market and reduced opportunities for profit. Another significant discouragement described by the companies visited were government requirements: regulations, cumbersome paperwork, and superfluous military specifications. While these barriers are not unique to this industry, they effectively bar newcomers and contribute to reducing the available pool of contractors qualified and willing to enter competitions. In Europe, on the other hand, the burdens of doing business with governments are less onerous. For example, Vickers reported a rise in the number of companies entering the market. Of particular interest is the number of software firms desiring entry, pulled by the continuing emphasis on command, control, communications and information integration requirements.

## CONDUCT

### Impact of Government Policies and Regulations

Excessive government policies and regulations were reported by US manufacturers as having a negative impact on the combat vehicles industry. Contractors at all levels, from primes through the lowest tiers, equate the excessive regulation to higher costs, inefficient production, and, in some cases, a suboptimized product. Areas receiving the bulk of the contractors' complaints included:

- Those policies and regulations which protect the government depot system, thus

preventing the private sector from competing on a "level playing field" for business the private sector views as critical to its survival.

- Those policies and regulations impeding the private sector from aggressively seeking international sales.

- Cost accounting standards.

We can expect the private sector manufacturers to continue to express strong collective concerns and lobby for changes in policies and regulations in the above areas. With little or no additional production of land combat vehicles for U.S. forces in the near future, the industry's survival will depend on gaining an increased share of depot work, greater international sales, and less burdensome cost accounting requirements.

**Government and Industry Relationships**

The defense drawdown has exacerbated the frustrations that have accrued from a long-standing adversarial relationship between the private sector and the government. When the defense business was booming, the strained relationship was tolerated by both sides. Now that the very survival of the combat vehicles industry is in question, the consequences of the strain are beginning to become apparent. For example, the private sector views as rhetoric the great debate over how to rationalize the defense industrial base. From its point of view, the industry is doing what is necessary to ensure its survival while the government has only studied and debated the issue.

**Pricing**

Domestic combat vehicles industry product prices reflect the cost of production in accordance with government specifications and procurement regulations, plus a relatively small margin. Net profits are very modest, ranging from approximately five to a maximum of ten to twelve percent. Throughout the industry, increases in productivity and efforts at cost reduction/avoidance are being pursued in an effort to decrease unit costs. However, government limitations on profit margin may diminish the attractiveness of cost reduction as a means to increase profits. Regardless of the level of industry efforts at increased efficiency and productivity, declining production rates will increase unit costs as the business base decreases and fixed costs must be covered by fewer production units.

Pricing for product upgrades appears to be relatively high. For example, a new Bradley fighting vehicle A3 variant may cost approximately $2.1 million versus an estimated $1.8 million to upgrade an A0 variant to A3 configuration. Likewise, the cost of extending the service life of the existing fleet of medium trucks is at least 60 percent of the cost of a new unit of the Family of Medium Tactical Vehicles (FMTV). These relatively high costs reflect extensive and detailed system requirements from DoD as well as increasing manufacturing costs. As with new vehicles, the cost of upgrades can be expected to increase as firms seek to retain profitability while production rates decline.

### Contribution to IR&D

Virtually every element of the private sector of the combat vehicles industry is pursuing independent research and development (IR&D) to varying degrees in accordance with individual corporate strategies. In most domestic companies, IR&D varied from 2 percent of sales at Oshkosh Truck to 4 percent of sales at FMC. On the other hand, BMY Corporation has no formal IR&D program of its own. BMY has traditionally operated as a build-to-print manufacturing facility, relying on outside R&D engineering when needed. IR&D outlays in the German, French and British components of the industry appear to be robust by comparison to those in US private industry. Some international IR&D is funded privately and generally constitutes a larger percentage of expenditures, but overall represents a lower total value. Generally, the international firms visited were less forthcoming than US companies regarding their IR&D.

## PERFORMANCE TRENDS

### SALES AND SHIPMENTS

Industry sales generally are moving downward in direct relationship with the defense budget. In some cases, sales appear level, but the mix is shifting from mostly U.S. sales to primarily international sales. Improvements to current equipment and significant international sales volumes are perceived by U.S. combat vehicles producers as the keys to maintaining a viable domestic combat vehicles defense industry. Sales of combat vehicles by European producers are as depressed as those in the US. However, traditionally low production rates make this decline somewhat easier to absorb than in the U.S.

### PRODUCTIVITY

Productivity enhancements are mixed. The uncertainty of future defense contracts has all but stopped capital investment oriented toward productivity improvements. Fortunately, plants remain fairly modern as a result of investments to support previous contracts. The current low production rates and single shift operations are not conducive to efficiency or full utilization of capacity. However, improvements do continue to occur as a result of worker and team recommendations through the Total Quality Management (TQM) and statistical process control (SPC) regimes. The US more formally follows TQM while European firms tend to team more informally or on an ad hoc basis. Effectively harnessing the skills of all participants in the production process has produced numerous improvements in the way work is scheduled and performed. Production rates will decrease, but productivity at the worker and factory level does not have to follow a corresponding path.

### PROFITABILITY

Orders for new vehicles in the combat vehicles industry have been shrinking since 1987 and are now in precipitous decline. Profits over the past five years have been low and are projected to continue to decline with reduced sales. Currently, they range downward from a maximum of twelve percent. By comparison, commercial products in the same companies are expected to produce 18 to 20 percent profit or be dropped. Moreover, IR&D and capital

expenditures continue to decline steadily across the industry. With the exception of General Dynamics, stock performance of defense firms has consistently lagged behind the Standard and Poor's 500 average. (General Dynamics' recent strong stock performance is the result of an increased cash flow from the sale of other corporate elements and reflects the success of the corporate strategy to divest itself of its predominantly defense oriented divisions.)

Despite the drastic reduction in U.S. as well as European requirements for combat vehicles, industry leaders display an aggressive attitude toward organizational changes, manufacturing efficiencies, and marketing strategies designed to maintain their respective firm's profitability. For example, as previously stated, executives of FMC and the Harsco Corporation have signed a letter of agreement to combine Harsco's BMY Corporation Division with FMC's Ground Systems Division. The transaction is expected to be completed in 1993. The combined organization will have estimated sales of approximately $1.2 billion in 1993. It will be jointly owned with FMC holding a 60 percent interest and Harsco holding the remaining 40 percent. Additionally, all of the US companies visited were drastically downsizing their defense operations, most by at least 50 percent. European combat vehicle manufacturers are similarly resorting to international teaming and creation of market niches to retain profitability.

Those U.S. companies which represent the tactical vehicle segment of the industry (Oshkosh Truck and AM General) have a much greater potential to integrate or diversify their production facilities into commercial product lines and are actively pursuing commercial markets. However, the companies that make up the armored vehicle segment of the industry have no potential for product transition into commercial lines without extensive restructuring and retooling. As noted above, two of these companies are combining their armored vehicle production facilities in an effort to share risks and reduce overhead and development costs. For highly diversified corporations such as FMC, the sharply reduced U.S. purchases of combat vehicles are unlikely to have a significant impact on the corporation's overall profit trends. Vickers, another highly diversified company, is experiencing its greatest losses in its automobile market segment. Although its defense segment is declining, Vickers' short and long-term business strategies are being adjusted to preserve its position in the defense market. Vickers and FMC seem to have a strong grasp and positive perspective on a long-term strategic plan.

It is clear that the significantly reduced defense budget will pose a formidable challenge to the combat vehicles industry. The sharp reduction in DoD sales will further erode already low profit levels -- the survivors in the industry will likely be those who:

- Develop profitable commercial or international markets,
- Develop a long term business strategy to take the necessary actions to remain in the market,
- Create affordable incremental upgrades to existing vehicles,
- Appropriately downsize to meet current and future low production rates,
- Compete for and win maintenance upgrade and overhaul work.

## INTERNATIONAL TRADE AND COMPETITION

Globally, the combat vehicles industry is strongly competitive. American and European

manufacturers are facing reduced defense budgets, over-capacity, and the need for international sales to remain in business. All of the companies visited by the study group were actively pursuing international opportunities. However, the American firms visited perceive very little or no US government presence, other than from the U.S. military, to assist in marketing US combat vehicles abroad. Other countries can rely to varying degrees on high level government officials to aid in the sale of their country's products.

U.S. firms in the combat vehicles industry have thus far enjoyed some success in the international arena. General Dynamics has contracts with Egypt, Saudi Arabia and Kuwait for almost 1000 tanks. FMC is providing Bradley fighting vehicles to Saudi Arabia. However, earlier this year, General Dynamics lost a $3.5 billion order to provide nearly 400 tanks to United Arab Emirates. France's Giat Industries successfully won the competition with its LeClerc tank. Another competitive bid was lost to Russia by FMC. United Arab Emirates bought Russia's BMP fighting vehicle rather than FMC's Bradley. However, substantial progress is being made in other areas. For example, FMC reported a co-production program with Japan for the Multiple Launch Rocket System (MLRS), and a joint venture with a Turkish private contractor to manufacture armored vehicles for the Turkish government. FMC also noted potential business with Korea and Kuwait. One company's comptroller reported 30 to 40 percent of company revenues were from international sources.

While the U.S. combat vehicles industry is restructuring to survive, it is imperative that government officials recognize that international sales benefit the US by allowing the combat vehicle industrial base to remain warm as well as retaining political and economic influence overseas. Thus, the U.S. government should lend its presence to support US products in the international arena, where politically appropriate. European combat vehicle firms may have more governmental support, but strong governmental export restrictions are reported to hamper international sales.

## OUTLOOK

### SHORT-TERM (1994 - 1999)

Potential short-term technological opportunities include insertion of vetronics (vehicle electronics), which will allow improved command and control, fire control, and on-board diagnostics, and will provide the architecture for the next generation of improvements.

### Tactical Vehicle Sector

This sector of the industry is well positioned to meet national security requirements during the remainder of this century. Recent tactical truck procurement has resulted generally in a modern fleet of these combat vehicles from the M998 HMMWV to the M1970 HET. These new acquisitions, combined with on-going service life extension programs, will meet our short term national security needs. Additionally, the new Family of Medium Tactical Vehicles (FMTV) program with Stewart and Stevenson will replace a significantly aged 2 1/2 ton vehicle fleet. The commercial demand for this type of truck means that the industrial base for these vehicles will remain relatively healthy. However, HMMWV production is scheduled to cease

in 1995, with no additional U.S. orders anticipated.

**Armored vehicle sector**

This sector of the industry also will be able to meet national security needs in the short-term. Recent decisions to upgrade the M1 main battle tank and the Bradley fighting vehicle, combined with some international military sales, will likely keep the production facilities warm through the end of the decade. These upgraded vehicles will insure that technological superiority is maintained on the battlefield. Of concern, however, is the capability to design, develop, integrate, and test future armored combat vehicles. Lack of substantial follow-on programs will result in significant downsizing of engineering staffs in these areas and a corresponding loss of expertise.

**LONG-TERM (2000 - 2015)**

The uncertainties associated with the armored and tactical combat vehicles industry will continue well into the next century. The problems encountered by United States defense contractors are similar if not identical to those encountered by our European allies. The future of this industry from the international perspective can be characterized in the following manner:

- Economic considerations rather than threat considerations will drive the industry;
- Survival of defense contractors will be dependent on "teaming" between domestic and international firms, and in some cases, teaming of national governments;
- Increased diversification and commercialization will sustain the industry;
- Competition for international military sales will remain fierce and substantially affect sustainment of the industrial base.

**Tactical Vehicle Sector**

Diversification of product lines will ensure this sector of the combat vehicles industry will continue to meet the long-term national security needs of the United States. Oshkosh Truck is an example of a contractor who is commercializing its product lines to improve chances for survival within the industry. The move from total reliance on military vehicles to commercial vehicles is also seen in the European market. Krauss-Maffei, IVECO, MAN, and Giat have significantly reduced their dependence on military systems. They have taken action either to enter commercial markets or to expand their existing commercial markets.

The move toward standardization of tactical combat vehicles is apparent in both the United States and European markets. This concept of a common family of vehicles will provide for high quality vehicles which can be fielded, operated, and maintained in a cost effective manner.

**Armored Vehicle Sector**

Ongoing changes in the threat, downsizing of the military, a weak economy, political

pressure, and industry overcapacity will continue to affect this portion of the U.S. industrial base in the next century. Similar problems are being experienced by the European allies we visited (Germany, United Kingdom, and France). New tank production in the United States and in Europe will continue at the minimum rate based primarily on international military sales. In view of these factors, it is unlikely the United States will produce a new generation of tank prior to 2015 - 2025. In the interim, we can expect our current tank fleet to undergo a number of upgrades and modifications until this timeframe. **Bottom line:** Our ability to produce the next generation of tank will depend on maintaining our engineering skills, technology base, and manufacturing technology base. Toward this end, funding R&D will be pivotal.

## RECOMMENDATIONS

For the U.S. combat vehicles industry to survive and prosper through the fundamental changes in its environment, and for DoD to continue to have a viable industry, a number of changes are recommended. Some changes are structural in nature, but most are regulatory or policy changes. Inherent in all recommendations is the most difficult change of all -- a change of attitude, or mindset, or some might say, culture. DoD, the Administration, and the Congress must learn to think of our industrial sectors as partners rather than adversaries. Punitive procurement policies and support of socioeconomic priorities often are contradictory to good business practices and smart management. A hodgepodge of contradictions and counterproductive requirements will make implementation of the recommendations problematic. Since it is unrealistic to expect radical statutory changes to occur during the next several sessions of Congress, the following recommendations focus on initiatives which might realistically be pursued:

- Incentivize the search for leveraging technologies, including both incremental and leap-ahead technologies, by investing in private R&D, and subsidizing consortia and potential dual-use R&D. Provide award fees or increase profits on R&D contracts as a means of preserving the integrated design teams within the industry.

- Budget and protect the funding for upgrade programs.

- Aggressively support international sales when they are consistent with international policy objectives, to create a partnership in which America's interests are advanced and manufacturers have access to wider markets.

- Present the impacts on the industrial base at milestone decision points during the Defense Acquisition Board briefings.

- Employ second sourcing of production requirements only when time and quantity requirements clearly demand it. Allow decisions by prime contractors to include business base and vendor survival considerations.

- Make best-value procurement the rule and not the exception. As part of this, require depots to compete on a level field with contractors for rebuild and upgrade work to increase the availability of work for private industry. Initiate action to revise the

legislated 60/40 rule regarding depot workloading.

- Let the free market determine which companies survive the defense drawdown, without direct government intervention.
- Pursue life-cycle support contracts with winners of production contracts.
- Support efforts to downsize within industry, such as facilitating the merger of BMY and FMC.
- Revise cost and accounting standards to match or more closely align with private industry best practices.
- Revise profit policy guidelines to exclude profit limitations on R&D contracts.
- Eliminate government restrictions on choice of suppliers by the prime contractors. Promote the preferred supplier approach both for government and industry use.
- Continue efforts to streamline and simplify acquisition.
- Use commercial products and processes wherever feasible for all but military-unique requirements (ruggedized, protection of troops, and so forth).

## INDUSTRY STRATEGY FOR SURVIVAL

Recommended strategies for private firms to assure profitability assumes that the US will not subsidize the existence of any company just to maintain its viability. According to one US company, there are six strategic concepts which will provide firms in the combat vehicles industry with a fighting chance to retain profitability into the next decade. These concepts are:

(1) Leverage what you know how to do.
(2) Invest for the future.
(3) Embody a total quality approach to doing business.
(4) Operate well in a high mix, low volume environment.
(5) Form strategic alliances.
(6) Market globally.

These concepts require innovative restructuring of the industry, not just downsizing, which will occur regardless of corporate strategies. Each of these six strategies are discussed below.

(1) Leverage: Most of the companies in the industry had a very clear idea of their business niche. This strategic concept says take what you do best and leverage from it. It is more related to the skills of the people and the needs of the market than to specific existing products. Yet this concept recognizes that a combat vehicle producer will be unlikely to compete successfully in the refrigerator business. There are large potential markets for fleet

upgrades, maintenance, and overhaul, both international and domestic. The Congress, Administration, public, and military must be shown the demonstrated benefits of a healthy private industrial base, as opposed to totally public-owned facilities. International commercial sales provide a path to profitability for combat vehicles and support equipment.

(2) Invest: This is a tough sell in a declining business base, yet we believe smart investments are key to survival in a rapidly changing and tough global market. Key investments include training the work force, research and development, and smart tooling. This longer-term view may be difficult to sell to the shareholders and board members. But a strategic investment in people, technologies, and the means of production can reap significant dividends and market share in the 5 to 10 year time frame. Additionally, significant dual-use technology dollars will be available, although the requirements for matching funds will discourage some companies from exploiting this opportunity. The industry must find innovative dual-use projects which help sustain combat vehicle production, while providing a payback to the country's economic growth.

(3) Total quality: The world market demands the best value product for its money. To achieve this, each member of a firm must be empowered to contribute their best, continuously improving the processes of management and production. The interrelationship between the "customer" and supplier, broad as this is, must be close and interactive. Senior management must provide the environment, education, and tools for their companies to continue the transition to a total quality approach.

Prime contractors within the U.S. industry are at various maturity levels in adopting a total quality approach. Subcontractors are essential to a total quality approach as well. This requires a fundamental change of corporate culture -- and easily can take a decade to fully mature. The combat vehicles industry must:

- Continue its development of a total quality approach, in conjunction with the subcontractor teams; and

- Work diligently to help its main customer, the U.S. government, continue its efforts to foster such an environment. Remember, the European combat vehicles industry is also aggressively pursuing the quality concept.

(4) High mix, low volume: Here, the Japanese concept of "lot sizes of one" applies. The economical high rate production of the eighties is gone. To cope with the drop in production, a number of approaches will be necessary:

- Virtual prototyping, using computers and advanced modeling techniques to help get it right the first time, such as those being pursued by the Advanced Research and Projects Agency.

- Agile manufacturing, which permits various products (high mix) to be built whenever possible using the same work force, production processes, and tooling.

- Core competencies which ensure talent availability for total product service from

cradle to grave.

(5) Strategic alliances: On a global basis, the successful firms of the next decade will be those who form strategic alliances with competitors, subcontractors, and governments. These long-term relationships will take a variety of business forms, depending on the product and the partners. Joint ventures, co-production agreements, mergers, and consortia should be the rule, not the exception. This can also provide access to otherwise closed markets. The US combat vehicles industry should cultivate a close relationship with the new Administration and Congress for the successful development of international markets.

(6) Global Marketing: During the remainder of the decade, the majority of new production combat vehicle demand will likely be international. The combat vehicles industry, supported by the U.S. government, must attack this market with its combined expertise.

## CONCLUSION

The combat vehicles industry in the U.S., and indeed worldwide, faces an extremely uncertain future. While the tactical mobility and striking power afforded by the US tanks, fighting vehicles and trucks of today have been proven beyond a doubt, the future of such vehicles is clouded in economics and political policy debate. Until this debate can be resolved into a more concrete vision to guide those involved in the combat vehicles industry, the industry's public and private components must pool their resources with ingenuity and innovation to survive. They must jointly pursue technological improvements and rationalization of capacity. Such teaming, within a framework of government acquisition reform and international political awareness, will provide a solid base for the combat vehicles industry of tomorrow. This in turn will help ensure that U.S. ground forces retain their ascendancy on future battlefields.

## GLOSSARY OF TERMS

AAV
Amphibious Assault Vehicle
ACE
Armored Combat Earthmover
AGS
Armored Gun System
APC
Armored Personnel Carrier
ARPA
Advanced Research Projects Office
AVLB
Armored Vehicle Launch Bridge
BFV
Bradley Fighting Vehicle
BMY
Bowen-McLaughlin-York
CEV
Combat Engineer Vehicle
CFV
Cavalry Fighting Vehicle
COCO
Contractor Owned, Contractor Operated
DoD
Department of Defense
FAASV
Field Artillery Ammunition Supply Vehicle
FMC
Food Machinery Corporation
FMS
Foreign Military Sales
FMTV
Family of Medium Tactical Vehicles
GDLSD
General Dynamics Land System Division
GFE
Government Furnished Equipment
GOCO
Government Owned, Contractor Operated
GOGO
Government Owned, Government Operated
HEMTT
Heavy Expanded Mobility Tactical Truck
HETS
Heavy Equipment Transporter System
HMMWV

High Mobility Multipurpose Wheeled Vehicle
IFV
Infantry Fighting Vehicle
IR&D
Independent Research and Development
IVECO
Industrial Vehicle Company
LAV
Light Armored Vehicle
MBT
Main Battle Tank
MILSPEC
Military Specification
MILSTD
Military Standard
MLRS
Multiple Launch Rocket System
NBCRS
Nuclear, Biological, Chemical Recon System
NDI
Non-Developmental Item
PIP
Product Improvement Program
PLS
Palletized Load System
R&D
Research and Development
RDT&E
Research, Development Testing and Evaluation
SIC
Standard Industrial Classification
SPC
Statistical Process Control
TACOM
US Army Tank-Automotive Command
TECOM
US Army Test and Evaluation Command
TQM
Total Quality Management

# Industry Studies

# #7

# Shipbuilding

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## INTRODUCTION

### Crisis in the American Shipbuilding Industry

As the 21st century rapidly approaches, all major American industries must contend with several complex and inter-related macroeconomic problems. The policies embodied by "Reaganomics" created a huge federal budget deficit as spending driven by social programs and defense outlays outpaced income by large margins. Our national debt grew ever larger as the trade deficit increased due to foreign protectionism against American exports. Volatile interest rates caused American businesses to develop conservative investment strategies. Similarly, private citizens responded by lowering their own savings and investment rates as unemployment increased while inflation remained low. Productivity increases were extremely low, especially as they related to our major foreign competitors such as Japan and Germany. In short, the economic woes faced by the new Clinton administration are far-reaching across the entire spectrum of American life. It is likely that government and industry leaders will place increased emphasis on development of a comprehensive national industrial policy that will attempt to address the nation's economic ills while preserving the viability of the defense industrial base.

Within this gloomy context, the American shipbuilding industry now teeters on the edge *of financial ruin.* Following World War II, the United States produced 48% of the world's commercial ships. By 1988, the commercial shipbuilding industry in the United States had virtually ceased to exist. As of April 1990, we produced less than one-tenth of 1% of the world's commercial ships. Japan and South Korea were producing 59%, with European countries accounting for another 18% (see Figure 1). The American shipbuilding industry had become entirely dependent on the United States Navy for new ship orders. Today, with Navy shipbuilding budgets expected to average about six ships per year through the end of the decade, American shipbuilders find themselves looking for ways to quickly regain a significant share of the international commercial market. As we will discuss in this paper, such a transition will be most difficult under the best of circumstances.

### Historical Perspective

How did we lose our competitive niche in the world shipbuilding market? A little historical perspective provides most of the answer.

Between 1955 and 1980, the U.S. shipbuilding industry was relatively healthy. It provided quality naval ships to the government and was competitive in the international market. Commercial deliveries averaged 20 ships per year and Navy shipbuilding orders generated approximately 50% of industry revenues. Total shipyard employment in 1980 was 187,000 workers.

With visions of a 600 ship Navy, Ronald Reagan began an enormous military buildup soon after taking office. A staunch supporter of free-market economic Darwinism, President Reagan eliminated government subsidies to domestic shipyards in 1981. There was little concern among members of the American shipbuilding industry, as they saw their coffers growing with the huge increases in naval ship orders. Even with the monopsonistic relationship with their government buyers, shipbuilders banked on increasing revenues while, at the same time, institutionalizing production processes that grew ever more inflexible in satisfying potential commercial customers. While capable of producing the most technologically complex ships in the world, American shipbuilders were losing the ability to build simpler, mass-produced ships that would satisfy time-to-delivery and cost requirements for commercial customers.

In the meantime, countries such as Japan, South Korea, and (The Federal Republic of) Germany granted substantial subsidies to their shipbuilding industries while modernizing production facilities and incorporating the latest technological innovations.

With the fall of the Soviet Empire, naval ship orders were drastically reduced. The 600 ship Navy had become nothing more than a historical curiosity. As the 1990s began, the number of naval ships on order could barely support five major shipyards. By 1992, the number of workers in the industry had dropped to 110,000.

**Where Do We Go From Here?**

Today, the United States' shipbuilding industry finds itself in dire straits, sorely in need of a viable means to reenter and prosper in the commercial market. Handicapped by excessive government regulations, outdated facilities, poor management practices, and overly powerful labor unions, American shipbuilders look to the government to reinstate subsidies to offset the advantages maintained by foreign competitors. At the least, they ask for a one-time "shot in the arm" subsidy to give them the wherewithal to position themselves competitively within the world's shipbuilding market. The government, on the other hand, resists requests for subsidies to American shipbuilders. Instead, it seeks to coerce its European and Far East Asian trading partners into eliminating their own subsidies. From either side of the coin, the emphasis is almost totally on leveling the playing field so that American shipbuilders can make the reforms needed to become a significant player in the international market.

<u>It is our contention that the health of the American shipbuilding industry is vital to our national security.</u> The industry should be a major contributor to our economic well-being in times of peace, and to our national defense in times of war. While fixing the subsidy problem is essential, we do not believe that mere leveling of the playing field alone will greatly enhance the chances for American shipbuilders to become effective in the international market. It is also vitally important that members of the American shipbuilding industry join together with an activist government to cooperatively modernize industry management practices, facilities, and technologies to meet the unprecedented challenge of reviving and reestablishing the viability of an all but defunct American relic - a thriving and vibrant shipbuilding industry.

## STRUCTURE

The American shipbuilding industry consists of public (government) and private (commercial) shipyards. Public yards are mainly responsible for overhaul and maintenance operations performed on U.S. Navy ships. While private yards may also perform repairs, their major focus is on new ship construction. Second and third tier suppliers of prefabricated components and raw building materials also form a significant portion of the overall shipbuilding industry.

The Active Shipbuilding Base (ASB) is comprised of 15 privately owned U.S. shipyards. Presently, five of the yards are without contracts for new ship construction.

In 1992, only one new commercial ship was ordered from American shipyards - a 24,000 deadweight tons (dwt) sulphur carrier to be built by the McDermott shipyard.

As of 1 January 1993, eighty-two naval vessels were under construction in ten American shipyards[1]. All but one of the ships were budgeted in fiscal years 1985 - 1992, with the LHD-6 in the FY93 budget (due for delivery in December 1997). However, sixty-five of the ships (79.3 %) are being built in only five (asterisked) of the shipyards as shown in the table below. These 65 ships account for about 90% of the total Shipbuilding & Conversion Navy (SCN) appropriation.

SHIPYARD SHIPS TYPES

| | | |
|---|---|---|
| American Ship Building Co. | 3 | T-AO; T-AGOS |
| Avondale Industries (*) | 13 | T-AO; LSD; MHC; T-AGS |
| Bath Iron Works Corp. (*) | 12 | CG; DDG |
| General Dynamics Corp. Electric Boat Division (*) | 11 | SSBN; SSN |
| Ingalls Shipbuilding, Inc. (*) | 16 | CG; DDG; LHD |
| Intermarine USA | 6 | MHC |
| McDermott Shipyards | 2 | T-AGOS |
| National Steel & Shipbuilding Co. | 3 | AOE |
| Newport News Shipbuilding (*) | 13 | SSN; CVN; MCM |
| Trinity Industries | 3 | T-AGS |
| | | |
| NEW SHIPS UNDER CONSTRUCTION | 82 | |

Further, only twenty-nine new ships are budgeted to be built for fiscal years 1994 - 1997 (with a profile of 6, 9, 6, 8 ships respectively)[2].

As naval shipbuilding continues to decline, the few surviving shipyards (and their suppliers) will be hard pressed to continue to operate as profitable business enterprises. The relatively strong yards will likely merge together and the also-rans will be forced out of the shipbuilding business entirely. There will probably be only one yard (either Newport News or Electric Boat) building submarines. Another likely scenario is that only one yard (either Bath Iron Works or Ingalls) will continue building guided missile cruisers (CGs), with the other yard building guided missile destroyers (DDGs). Competitive procurement will become a relic of the past, and the defense industrial base will become less capable of supporting a surge capacity in times of national emergency.

## CONDUCT

### Commercial Shipbuilding

Commercial ship prices are primarily established by the international market. As indicated above, U.S. shipyards are not competitive internationally largely because of subsidized foreign competition and inefficient means of producing ships within desired delivery dates and costs. U.S. labor rates are competitive with those of other members of the international market. However, commercial ships built by U.S. shipyards tend to be over-designed and take up to three times as long to deliver as foreign built ships. Thus, they are too expensive for international shipping operations.

### Naval Shipbuilding

The prices of naval ships are extremely high due to two factors. First, developing the most technically complex ships in the world drives the costs of production to unprecedented levels with the implementation of each new ship design or technological innovation. Second, overly cumbersome federal laws and acquisition policies requiring strict adherence to complicated production and accounting procedures drive costs even higher.

Because of the monopsonistic relationship with its single customer, American naval shipbuilders have been forced to accept minimal profit margins. This has been the case whether they worked under cost-plus contracts (as was popular in the early 1980s), or fixed-price contracts as in the current vogue.

### Work Force

The American shipbuilding industry is comprised of 20 trades. Most shipyards have apprentice programs that train new workers. In many shipyards, consolidation of the trades is taking place and workers are being cross-trained to perform multiple functions. Approximately 90% of all shipyard workers belong to one of the major unions that represent the various shipbuilding trades.

The average hourly earnings of private shipyard workers in the United States are comparable to those earned by their foreign counterparts. In fact, South Korea is the only major shipbuilder with a lower hourly wage rate than the U.S.

| COUNTRY | 1990 $/HR |
|---|---|
| Germany | 26.50 |
| Norway | 24.36 |
| Denmark | 21.36 |
| Italy | 19.22 |
| France | 18.60 |
| Japan | 15.80 |
| USA | 15.50 |
| South Korea | 10.00 |

**R&D Outlay and Capital Investments**

The U.S. shipbuilding industry has not made any substantive investments in commercial shipbuilding research and development. There have been funds spent for naval research and development.

The industry's capital investments since 1970 have totaled more than $5 billion. In 1992, the U.S. ship construction and ship repair industry invested more than $215 million in the upgrade and expansion of facilities. Much of this investment was to improve efficiency and competitiveness in the Navy's construction, repair and overhaul projects, but little of these monies were spent towards modernizing to compete in the commercial market. This year, the industry plans to spend about $142 million in the upgrade and expansion of facilities. These capital investments will include improvements to existing and new basins, floating drydocks, cranes, and automated equipment. Investments will also be made to implement highly mechanized modular techniques for the fabrication of large subassemblies and pre-outfitting of ship components.

## PERFORMANCE

Overall, the U.S. shipbuilding industry has not performed well in terms of positioning itself to survive in the future. Even with the huge naval buildup, many American shipyards went out of business in the 1980s, and none of our current shipyards are ready to produce commercial ships today - even if it became profitable to do so.

The efficiency of the U.S. shipbuilding industry is difficult to evaluate. On the one hand, American shipbuilders have successfully produced hundreds of the most technologically advanced surface and subsurface vessels in the world. While there have been controversies over the cost and delivery schedules for some of these ships, it is indisputably clear that the U.S. Navy has the finest warships of any country in the world.

On the other hand, the industry is poorly prepared for entry into the commercial shipbuilding market. Business decisions and investments focused solely on government work leaves the industry high-and-dry now that naval shipbuilding is in a rapid freefall. Process improvements are constantly being made, but these are almost exclusively targeted at continued levels of naval shipbuilding. As an example, General Dynamics, Electric Boat Division in Groton, CT, invested millions of dollars in building new covered shipyards, purchasing automated welding machines, management reorganization, and consolidating union trades. These steps have significantly reduced the delivery cost of a ballistic missile submarine. Similar reductions in overhead and increases in productivity are being realized at Bath Irons Works, Bath, ME, (primary contractor on the Arleigh Burke DDG), Ingalls in Pascagoula, MS, and Newport News in VA.

In short, those few shipyards remaining as active naval shipbuilders continue to invest in means to improve their "technological forwardness", but the industry as a whole is squandering potentially valuable capital and labor resources. As shipbuilding companies continue to go out of business or merge with their more successful competitors, a great deal of excess capacity is created. Equipment is sold, shipyards are converted into waterfront restaurants and highly skilled workers move to other careers (or unemployment).

With very few exceptions, the corporate management of domestic shipyards seems to be counting on the government to solve all their problems for them. Some remain optimistic that the strategies that worked well in the past will carry them through the tough times ahead. Others recognize that entry into the commercial market is essential for survival, but still refuse to take steps to modernize their management and ship construction processes until the government takes the lead.

## ASSESSMENT

### Implications for the Department of Defense

Unless the U.S. shipbuilding industry can reinvent itself as a major player in the global commercial market, it will be unable to support future requirements for surge capacity in times of national emergency. Mobilization and reconstitution efforts will fail to generate a sufficient force if ships can only be built in one or two shipyards. According to the estimates of John Stocker, President of the Shipbuilders Council of America, U.S. to offset reductions in naval ship construction, U.S shipbuilders must build 30-50 commercial ships per year to maintain their present shipbuilding capacity. Unless we are successful in this endeavor, shipyards will be converted to other industries and a major blow will have befallen the defense industrial base.

The Persian Gulf War demonstrated that the U.S. still has a need for a massive sealift capability. Even as production of warships phases down, American shipbuilders can and must use their freed-up capacities to construct roll-on/roll-off vessels (Ro/Ros). Further, construction of merchant ships that can be used by the military during times of national crisis pays dividends to both the commercial and defense sectors of our economy.

## Implications for the National Economy

Aside from having dire effects on our military capabilities, the decline of the shipbuilding industry continues to have deleterious effects on our national economy. Figures 2 and 3 show that unless the American shipbuilding industry becomes a viable player in the international market, a significant number of jobs will be lost. The average number of shipyard employees will continue to drop to approximately 28,000 (a drop of some 159,000 since 1980) by 1998. Further, there will be even greater losses of jobs in the supplier, second-tier, and support sectors of the shipbuilding industry.

## The Future Looks Bright - If Only We Join In

Is there any good news in all of this? The answer is yes - if we only join in! Several studies performed in this country and abroad indicate that the market for new commercial shipbuilding looks very promising. The world's merchant fleet (especially tankers - see Figure 4)is rapidly aging and will need replacing in the latter part of the 1990s and the first two decades of the next century. These studies forecast that the current gross tonnage in shipbuilding production will more than double by the year 2000. It is expected that this upturn will continue at an annual level of 30 million dwts.

The anticipated replacement of the world's tanker fleet during this decade is expected to be the vehicle to propel U.S. shipbuilders back into commercial construction. In 1990[3], the percentages of tankers more than 15 years old included 47% of the oil tankers, 31% of the bulk carriers, 24% of the container ships, 49% of the general cargo ships, and 29% and 42% of the LPG/LNG and chemical carriers respectively. Orders for replacement of most of these ships will be placed during this decade.

The atmosphere for American participation in the coming shipbuilding boom is getting better - but waiting for miracles will not get the job done. Worldwide prices for new ships are increasing as the costs of labor and materials to our foreign competitors rise. The Organization for Economic Cooperation and Development (OECD) is actively pursuing development of a broad policy by which Far Eastern governments would eliminate or significantly reduce the subsidies they provide to their shipbuilders. At the same time, members of the European Community (EC) have been lowering their own subsidies. If the U.S. government can help bring these changes about, then American shipbuilders will have an excellent chance of competing in a growing global shipbuilding bonanza - but only if they are ready to produce commercial ships at acceptable prices and delivery rates.

Thus, the American shipbuilding industry will enter a critical period near the end of this decade. By 1998, the vast majority of the Navy construction will be near completion. Contracts for new designs are not expected to be awarded until after the turn of the century. The out-years period for submarine construction is even further away to about 2005 for the start of the anticipated new "Centurion" class nuclear attack submarine. This will significantly impact both General Dynamics, Electric Boat, and Newport News Shipbuilding. The Aegis shipbuilding programs are nearing completion, and will either be completed (cruisers), or have their numbers reduced (destroyers). This action will significantly impact the two Aegis building yards of Ingalls Shipbuilding and Bath Ironworks. The fate of some of the Gulf Coast smaller

shipbuilding yards is somewhat more positive. The protection afforded by the Jones Act, coupled with Navy auxiliary and other government construction should help them survive. As emphasized earlier, the large-ship construction sector of the industry. which is supported almost totally by Navy warship contracts, must shift its focus away from these Navy construction contracts, and work to become a viable competitor in the commercial shipbuilding and repair sectors. If they cannot make this transition, they will go out of business.

Industry leaders with whom we talked recognize that restoration of shipbuilding subsidies is highly unlikely, and they expressed a desire to ultimately make it on their own. Shipyards and suppliers want the U.S. government to be more proactive in encouraging allied governments to specify U.S. equipment, where appropriate, in their government and navy shipbuilding programs, and to assist in leveling the playing field in international markets. Additionally, they see the military sealift construction program as an essential factor in the survival of a competitive U.S. shipbuilding industry. The major yards could use participation in this program to help them transition to commercial shipbuilding activities, while permitting them to keep the minimum sustaining employment base for survival. Leaders in industry expressed interest in having a period of protection from foreign competition, and financial assistance to owners/builders -- similar to foreign government loan guarantees, etc. -- for building a line of merchant vessels to help leapfrog them into international competitiveness in the industry.

In the past, the U.S. industry has lead the way in developing and building new and innovative vessels. Reentry into the LNG construction market is a possible avenue for at least one of the major yards to regain international market share. Construction of products of this nature suits the U.S. work force best. With the mature, well paid labor structure in the U.S., construction of vessels requiring a high degree of technical competence and sophistication are areas where we can compete effectively. The Oil Pollution Act of 1990 requirement for double-hull construction or conversion of tankers is expected to generate a market for U.S. shipbuilders, and Gulf Coast shipyards continue to invest in improvement of facilities in anticipation of receiving a fair share of this work. Entry into the design, construction and conversion of cruise, dining and gaming ships by U.S. yards is increasing. These projects have been generated by the enactment of legislation by the states permitting riverboat gambling. Several Small Waterplane Area, Twin Hull (SWATH) day cruise ships -- chosen for their superb seakeeping and riding characteristics -- are in the planning stages or under construction.

**All Naval Construction Isn't Going Away**

Naval ship construction and repair work will continue to be the primary source of employment for the major full-service shipyards for the foreseeable future. Employment in the industry will continue to decline substantially as the Shipbuilding and Construction, Navy (SCN) budget diminishes. The 1994 SCN budget of $4.3 billion is $1.7 less than the 1993 SCN budget, and is $4.1 billion less than the total budget plan in fiscal 1993[4]. The Defense Department bottom-up review of major weapons systems procurement could have an adverse effect on construction of CVN-76. Construction of CVN-76 is considered critical for maintaining Newport New Shipbuilding as a viable shipyard for nuclear carrier overhauls, nuclear refuelings, and as a potential source for nuclear submarine construction[5].

Construction of a third Seawolf submarine or additional "Improved Los Angeles" class submarines is critical for Electric Boat in order for the company to maintain a minimum sustaining employment base for future submarine construction. All major yards are marketing their products internationally -- Bath Iron Works would like to export FFG-7 variants, while Newport News is marketing its FF-21 (a $40 million competitor with designs from Germany and France) -- and competing for foreign commercial and military conversion and repair work. Ingalls Shipbuilding recently won a $200 million contract to overhaul and modernize two Venezuelan Navy frigates. The effects of the Clean Air Act and the Oil Pollution Act should stimulate business for the U.S. shipbuilding and repair industry in the out-years as industry tries to comply with their requirements. Satisfying the construction demand for double hull replacement tanker vessels and barges, and backfitting mandated vapor recovery systems to current vessels should keep smaller yards busy for the foreseeable future.

## RECOMMENDATIONS

If the American shipbuilding industry is to survive in the future, all major players must integrate with each other to develop a single strategy for the industry. The major players include: the shipbuilders/yards, the ship owners, the labor unions, academia, and the U.S. government.

Within the purview of these players, a strategy focused around five critical areas of interest should be created.

- Provide an Equitable Global Market
- Promote Competitiveness
- Promote Process Improvements
- Expand Research and Development
- Create an Interim Market

These five areas will be discussed below.

### Provide an Equitable Global Market

The successful shipbuilding nations in the current world marketplace provide significant subsidies to their respective shipping and/or shipbuilding industries. When the U.S. government, during the Reagan administration, eliminated American subsidies to the shipbuilding industry in 1981, it virtually guaranteed the decline of U.S. competitiveness in the world shipbuilding market. Current attempts by the government to eliminate direct and indirect foreign government subsidies have not been successful. Recently proposed legislation such as the ill-conceived Gibbon's Bill would accomplish little more than alienating our foreign competitors, possibly leading to open trade wars.

We believe that America needs to retain a viable and healthy shipbuilding industry. Because it will take a long time for the OECD to successfully induce foreign governments to eliminate subsidies to their shipbuilding industries, the U.S. government must initiate a one-time subsidy program for its own shipbuilding industry. Such a program should be limited in its duration, similar to that provided to Chrysler Motors and Harley-Davidson, and provide "protection" for the shipbuilding industry until it is has reorganized and can compete on an equal level with the other shipbuilding nations of the world. This program would provide such "protection" in the form of construction and production assistance, inexpensive loans and tax credits, research and development investment, and capital equipment and process improvement initiatives.

**Promote Competitiveness**

*The American shipbuilding industry must take an active role in determining how it can become competitive through its own initiatives.*

First, the industry should promote and support legislation to help level the playing field for U.S. shipbuilders. An example is the National Defense Authorization Act of 1993, which provides a National Defense Sealift Fund for the construction, purchase, alteration and conversion of (DoD) sealift vessels[6]. It should seek to enact proposals submitted by the Senate Merchant Marine Subcommittee which positions U.S. importers and exporters effectively in trade markets, increases competitiveness of U.S. shipbuilding in the world market, establishes private/public partnerships to achieve national defense purposes, and sustains industry jobs[7].

Second, the industry should develop builder/owner partnerships which foster cooperative efforts to obtain shipbuilding contracts. Examples of such "partnering contracts" can be found between Chevron Shipping and Singapore's Jurong Shipyard and Lisnave of Portugal[8], Britain's Contship Group and the German Schichau-Seebeckwerft yard[9], and the U.S. Shipbuilding Consortium, Inc. of Ole Skaarup[10].

Third, the industry should adopt an internationally recognized quality assurance program such as ISO 9000[11]. This would allow U.S. shipbuilders to gain credibility in the international commercial ship market, where such a program has already gained wide acceptance. Such a standardization process would include certification for approved suppliers as a natural follow-on step.

Fourth, the industry should set a high priority on conducting market research. Fundamental to improving competitiveness is understanding where the future shipbuilding market is going to be centered. The industry must take a proactive role in developing a strategy which would offer the best opportunities to be a part of the future market.

Fifth, the industry should encourage new financial management practices which focus on a complete re-vamping of the corporate financial statement. This could be accomplished

managed, and assessing different incentives for stock options/shareholders. Additional effort could be directed to organizational restructuring and cooperative financing agreements with other shipyards such as those between Newport News Shipbuilding and Metro Machine.

**Promote Process Improvements**

The American shipbuilding industry must rethink and initiate modern practices in the way in which ships are actually designed and built.

Automation and robotics must be instituted in the construction process wherever possible in order to reduce the direct and indirect labor costs associated with ship manufacture. Examples of this advanced technology can be found in every facet of the shipbuilding process from pipe and sheet metal fabrication to welding, painting, riveting, material handling/processing and even the design and layout process of the vessel itself.

Closely aligned with automation and robotics is the reeducation and training of the workforce to use such equipment in the production process. As new technologies and construction practices are introduced into the manufacturing process, the remaining workforce must be competent in their application, use and support. Additionally, cross-training of employees in more than one production/process skill area is essential to maintaining an effective, economical production process in times of diminished workload.

A state-of-the-art methodology for actual ship construction must be incorporated into the shipbuilding process. The application of "down-hand" welding through enhanced modular construction and loading, such as that found at General Dynamics Electric Boat Division, to significantly reduce construction costs is one example. A "one-stop" source of supply for entire ship systems modules - design, construction and delivery - such as the partnership between Wartsila Diesel and General Dynamics Electric Boat Division[12] to produce a complete ship's propulsion module ready for delivery to the shipbuilders yard is another.

Facilities and equipment design must also be improved to more economically and efficiently produce a completed vessel. An example of this kind of process improvement is found at the Quonset Point facility of Electric Boat for manufacturing nuclear submarines.

**Expand Research and Development**

A healthy shipbuilding industry must promote and provide for an expanded research and development program. A program which supports product and process research and development is crucial to enhance the competitiveness of the American shipbuilding industry within the global market.

More use must be made of the National Shipbuilding Research Program, a research consortium composed of representatives from government, industry and academia. The program incorporates federal R&D funds, University Grants, government facilities and independent research (conducted by shipbuilders), and allows its members to

exploremethodologies which will enable the shipbuilding industry to be more effective and productive.

Expansion into new hull, cargo and propulsion designs is essential to remaining competitive in future shipbuilding programs. Such areas as SWATH design, improved cargo holds for Liquified Natural Gas (LNG) carriers and multi-engine outfits for vessels to more effectively operate over the duration of a voyage[13] are examples of these new research and development initiatives.

The introduction of computer aided design and computer aided manufacturing (CAD/CAM) technologies into the design and construction process is fast becoming the most effective way to develop, design, test and manufacture a ship. Inherent in this technology is the development of expanded electronics operations for the factory manufacturing and individual product lines in the construction process.

New developments in information systems and engineering are critical areas in the overall concept of research and development. As an example, the Odense Steel Shipyard in Denmark has developed an advanced shipbuilding system based on a Local Area Network (LAN) and open system architecture which goes beyond CAD programs by establishing a three-dimensional, topographical model of the entire ship with all components and links it to an automated production line[14].

**Create an Interim Market**

Recognizing that the American shipbuilding industry cannot become competitive in the world market place overnight, an interim market has to be created which would allow the industry to progressively develop the skills, processes, and technologies discussed above. This interim market would then provide the foundation and "yardstick" for future design, production and delivery of vessels by the industry.

A part of creating an interim market has already begun through the creation of a comprehensive National Sealift Program. This program will provide the industry with both mid-term and long-term business in new construction, conversion and repair work and design and engineering concepts.

A second area of what could form the basis for an interim market is the expansion of the Foreign Military Sales Program. The U.S. is already recognized as the leader in Naval warship technology and construction. A logical outgrowth of this area would be the manufacture and sale of this product to foreign governments. Such a practice is already in place with existing/decommissioned ships, but could be expanded to include new construction as well. Although it will be important to guard against technology transfer, U.S. shipyards should be afforded the opportunity to market this expertise on the world market. Such an effort would enable the American shipbuilders to retain critical military shipbuilding skills in a time of reduced domestic Naval construction.

## SUMMARY

As we enter the middle third of the 1990s, the United States shipbuilding industry suffers from all of the maladies affecting other major industries within our national economy as well as some additional ills that are uniquely its own. Long dependent on the Navy as its sole customer, American shipbuilders are faced with reentering the international commercial market under the most difficult circumstances. Their management and production methods are grossly inadequate to survive in the fast-paced commercial market where they are unable, at present, to meet the delivery schedules and construction costs of foreign competitors subsidized by their own governments.

If the U.S. shipbuilding industry is to survive (and eventually prosper), leaders of industry, government, and academia must join together to devise a multi-disciplinary strategy to improve the competitiveness of commercial ship production processes. While naval shipbuilding will likely continue at low levels, the only way to ensure a future military surge capability is to utilize current and expanded shipbuilding capacity and already trained human resources for entry into the international market. To do any less would jeopardize the future defense of our nation.

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# INDUSTRY STUDIES

# # 8

# AIRCRAFT

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## PARTICIPANTS

### Students

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Mr. Jerry Abbot

Mr. Fred Meyers

Col Mike Smith

Dr. Herman Stekler

Lt Col Chris Stoops

## PLACES VISITED

### Domestic

| | |
|---|---|
| Boeing Helicopters | Philadelphia, PA. |
| Pratt & Whitney Aircraft | East Hartford, CT. |
| Aerospace Ind Assoc of America (AIA) | Washington, DC. |
| McDonnell Douglas | St. Louis, MO. |
| Boeing Aircraft | Seattle, WA. |
| Shultz Steel | South Gate, CA. |
| Ciba Composites | Anaheim |
| Northrop Aircraft | Palmdale |
| Lockheed Aircraft "Skunk Works" | Palmdale |
| Douglas Aircraft Company | Long Beach |

### International

| | |
|---|---|
| British Aerospace | Lancashire, UK. |
| EH Industries | London |
| UK Ministry of Defence | London |
| Rolls Royce | Bristol |
| Airbus | Toulouse, France |
| Aerospatiale | Toulouse |
| SNECMA | Villaroche |
| Dassault | Bordeaux |
| DGA | Paris |

### Guest Speakers

| | |
|---|---|
| Mr. Adrian D. LeRoy | Douglas Aircraft |
| Mr. Michael Ciminera | Grumman Corporation |
| Mr. Sergei Sikorsky | Sikorsky Helicopter |
| Mr. Harold Fogg | General Electric |
| Mr. Robert Smith | T. Rowe Price |
| Mr. Hans Westphal | Boeing |
| Mr. Vincent L. Rausch | NASA |
| MS. Sally H. Bath | Commerce Department |

# THE AIRCRAFT INDUSTRY

## INTRODUCTION

The aircraft industry is one of the premier manufacturing sectors of the American economy — accounting for over one quarter of the dollar value of our exports. American aircraft companies have been leaders in military and commercial aircraft, both fixed and rotary wing, since the dawn of the age of flight. Our aircraft industry is still the world's technological leader, but the days of large defense budgets and unbridled commercial expansion are gone. In today's competitive global market, it will take more than past performance to succeed.

In both the military and commercial sectors, the world aircraft industry is suffering from overcapacity — there are more players in the game than can be supported. Downsizing is inevitable, but who survives remains unclear. The outlook in the years ahead is mixed. Overcapacity presents the most serious problem for the military aircraft and helicopter sectors of the industry. The end of the Cold War caused a dramatic reduction in American defense procurement, while foreign military sales, although beneficial for domestic industry, present moral issues for the world community. There will also be reduced demand for new commercial aircraft for a number of years, followed by a rebound as traffic growth improves and the airlines' excess capacities are reduced.

Our studies left us with an appreciation of the intensely competitive nature of this premier industry and a cautious optimism for its future — after a painful period of restructuring.

This report examines the aircraft industry (domestic and foreign), looking first at its **structure** — how the industry is organized and who the players are. The report then addresses the **conduct and performance** of the industry — how it does business, who its customers are, how they interact, and how well it is doing. Finally, various **industry and government options** to help improve the U.S. aircraft industry's future are noted and discussed.

## STRUCTURE OF THE INDUSTRY

### General

The U.S. aircraft industry — comprised of some 15,000 prime, major subsystem, and lower-tier contractors — is divided into five general sub-groupings:

- Large commercial aircraft (over 100 seats)
- Military fixed wing aircraft
- General aviation
- Aircraft propulsion systems
- Helicopters, civilian and military

The largest sector, commercial aircraft, is composed primarily of revenue passenger carrying aircraft. This analysis focuses only on the large commercial aircraft (over 100 seats) segment of the sector. The second sector, fixed wing military aircraft manufacturers, is largely organized around meeting national defense needs with unique tactical and strategic aircraft not normally associated with commercial applications. General aviation represents another major sector, but due to limited time and resources, and its relative unimportance to defense and the economy, it was not analyzed in this report. Aircraft propulsion systems include a wide grouping of power plants — from small piston engines to extremely large turbofans. This analysis primarily concentrates on jet engines associated with commercial and military applications. For the purposes of this report, the helicopter sub-group combines both military and commercial use rotary wing aircraft into a single category.

The aircraft industry is extremely competitive, technologically advanced, with prohibitively expensive entry barriers. Due to the downward market trends over the last several years, the pool of experienced employees to draw from is eroding. From highly skilled workers to sophisticated tooling, successful companies must invest significant resources in continuous process and product improvements.

Although there are 15,000 companies engaged in the aircraft industry, major prime contractors number less than a dozen and represent an oligopoly. While commercial aircraft manufacturers operate under free market conditions, military prime contractors function in a monopsony with the government as their only customer.

In many cases, the required capital equipment represents an insurmountable entry barrier. The cost of launching a new large turbofan engine exceeds $1 billion, while the developmental costs of a new commercial passenger aircraft are about $6 billion. Hence, there is little wonder why we don't see any new companies entering this sector. In fact, due to government cutbacks and a reported $6 billion in airline industry losses for 1992, many companies may be forced to close their doors or move into other product lines. The aircraft industry has a measurable impact on the overall U.S. economy (1 percent of GNP). Average employment in this sector during 1992 was 1,063,000; down 10 percent from the previous year. Though total sales for military and commercial sectors were $89.9 billion for 1992, new orders fell 23 percent to $97 billion for the same period. Overall reported profits for 1992 were $2.6 billion.

Exports and trade surplus make the aircraft industry one of the U.S.'s most treasured. The aircraft industry exported $44 billion in 1992 and maintained an overall trade surplus of $31 billion. The aircraft industry also represents a major investment in capital equipment, with aircraft prime and sub-contractors spending $4.8 billion in new capital equipment last year.

International alliances and joint ventures have become more prominent as our aircraft and engine companies look to offshore markets and deeper financial pockets as ways to reduce the risk associated with aircraft development. Defense companies are also exploring new business opportunities for diversification into non-traditional business areas. However, they are careful not to "go it alone," often teaming with commercial firms that know how to market a product in the civilian economy.

The following sections examine unique sector aspects of the domestic and foreign markets, sales, and entry barriers.

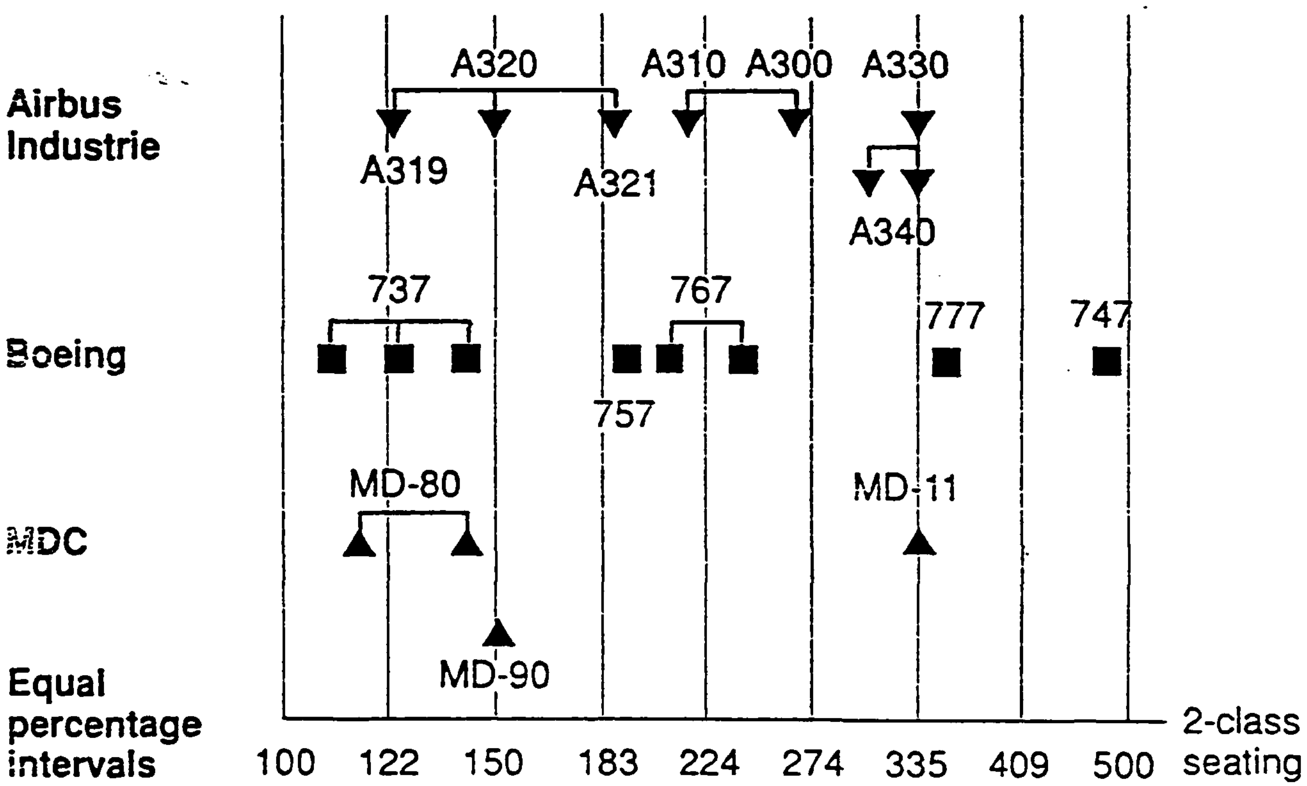
**Commercial Aircraft Manufacturers**

There are three aircraft manufacturers that dominate the worldwide large commercial aircraft sector:

- Boeing Company (Boeing Commercial Aircraft)
- Airbus (European consortium — France, Germany, England, and Spain)
- McDonnell Douglas Company (Douglas Commercial Aircraft)

Boeing retains approximately 60 percent of the world's large commercial aircraft market (excluding former Soviet Union). Airbus' market share is roughly half that of Boeing's but remains twice that of Douglas'. One of the primary causes for this distribution of market share is the classes of aircraft each company offers. Only Boeing has a range of products that covers all six commercial airline classes, with Airbus offering five and Douglas only two. (Figure 1)

**Figure 1. Aircraft Product Family**



With the exception of a very small percentage of sales to domestic and overseas military customers, the commercial aircraft industry depends on the business cycle of the airline industry. Faced with overcapacity, commercial airlines suffered a $6 billion combined loss for 1992, resulting in postponed or cancelled aircraft orders. In addition, poor economic conditions have all but halted the replacement of older, less efficient aircraft with new purchases. Despite the reduced operating costs, the airlines simply can't afford to replace older aircraft.

Boeing has begun a major strategy initiative to cut overall costs by 25 percent through lower development and production costs. The impetus for this initiative came after Airbus made major inroads into Boeing's market last year, securing a 50 aircraft deal with United Airlines, historically Boeing's largest customer. Boeing continues to build upon its partnership with Japanese heavy industries, evidenced by Japan's 20 percent share in the new 777 development and production. Boeing launched the 777 to round out their family of commercial aircraft and to fill a projected market need for the mid-1990s.

Europe's Airbus consortium is a virtual company that delegates its manufacturing operations to four different aircraft companies:

- France's Aerospatiale
- Germany's Deutsche Aerospace (DASA)
- Britian's British Aerospace (BAe)
- Spain's Construcciones Aeronauticas (CASA)

Airbus is completing testing of two new aircraft, the A330 and the A340, with the A340 competing directly with Boeing's 777. Airbus has maintained its position as the number two aircraft manufacturer steadily increased its market share. Airbus has come under criticism from the United States over the level of government subsidies for aircraft development and production. After years of negotiation, an agreement was reached in 1992 precluding the participatory governments from subsidizing Airbus's production efforts and limiting funding for developmental efforts to 33 percent.

Airbus has led the industry in the application of technological advancements in commercial aircraft. They were the first company to offer fly-by-wire flight control systems, side- stick flight controllers, and to place fuel in the empennage as a method of improving aircraft range performance. It is unclear at this point as to who bears the liability for Airbus products. There are indications that aircraft liability is borne by the host nations, providing Airbus a distinctive advantage over its U.S. competitors, which bear the burden.

Douglas Commercial Aircraft Company, whose sole business is the MD-80/90 and MD-11, was separated in 1991 from all other McDonnell Douglas aerospace activities. Douglas continues to lose market share, primarily to Airbus. Douglas aggressively sought overseas partners as a way to obtain necessary funding to launch the MD-12, and at one time was reportedly close to completing an agreement with Taiwan. However, Taiwan backed out at

the last minute as Douglas announced that it was delaying its launching of the MD-12. The MD-12 was targeted at competing somewhere between the 777 and the 747 markets. This plane would have broadened Douglas's product family, allowing them to compete in additional classes.

### Military Aircraft Manufacturers

The majority of the world's leading military aircraft manufacturers are located in the United States: Lockheed, McDonnell Douglas, Boeing, and Northrop. Lockheed's recent purchase of General Dynamics' Fort Worth tactical aircraft division will allow it to challenge McDonnell Douglas as the dominant military aircraft manufacturer in the 1990s. By the end of the decade, only McDonnell Douglas and Lockheed will continue to produce aircraft for the U.S. military market. McDonnell Douglas' C-17 is the only new transport aircraft currently entering production, and Lockheed is the prime on the F-22 fighter scheduled to become operational in 1997.

With the industry facing continued defense budget cuts, other historic U.S. manufacturers of military aircraft such as Grumman, Rockwell, General Dynamics and Boeing are pursuing other directions for the 1990s. These companies are all discussing new business ventures in terms of proposing new modifications or derivatives to existing aircraft. However, Boeing is turning away from non-profitable military contracts and concentrating on its profitable commercial aircraft market.

With B-2 production capped at only 20 aircraft, Northrop Aircraft Division sold its executive aircraft and corporate headquarters, and combined overall operations in an effort to improve its cash flow. They will cease to be a major producer of large aircraft and will focus on continuing their role as a major sub-contractor for the 747 and FA-18. Grumman, out of the new aircraft business, is hoping for upgrades to its E-2C, EA-6 and F-14 until next century replacements enter the fleet. Rockwell also is reducing its emphasis on defense, but remains a leading NASA contractor. The only bright spot on the horizon for new fixed wing military aircraft is the Navy's A/FX fighter attack aircraft and the Advanced/Short Takeoff and Vertical Landing (ASTOVL) aircraft. Both programs are in early concept formulation phase with production some 10-15 years away.

Many small businesses, and second- and third-tier companies, have abandoned the defense market. The certification policies of many prime contractors have forced their suppliers to seek non-defense products or close down. The military sector downsizing will keep the supplier base extremely low. The labor-intensive and capital-intensive nature of the industry; the high technology requirements to design, develop, and manufacture competitive aircraft parts; and the decreasing number of actual aircraft procured almost preclude a new corporate venture.

However, European military aircraft manufacturers such as British Aerospace, MBB, and Fiat, have joined forces to produce the EFA (European Fighter Aircraft). Between the partnered countries and the prospect for exports, the companies believe there is enough production potential to move forward with this program. France's Dassault Aviation is

currently developing the Rafale to meet their future fighter/attack aircraft needs. To realize a profit on the Rafale program, Dassault will rely heavily on the foreign export market.

### Aircraft Engine Industry

The aircraft engine industry is not immune to the effects of the defense drawdown, or to the slow commercial aircraft market. In fact, it is directly dependent on aircraft sales. While major players seem set to weather the storm, there is no significant relief seen within this decade. The two main U.S. manufacturers of military and civil jet engines are:

- Pratt & Whitney (P&W)(division of United Technologies)
- General Electric (GE)

The once dominant lead of American engine manufacturers has significantly eroded over the past ten years. Worldwide in 1982, GE (21 percent) and P&W (54 percent) accounted for 75 percent of all large commercial aircraft engine sales by units shipped. At that time, their only serious competitor was Britain's Rolls-Royce (RR), with 21 percent of the market. By the end of 1993, estimates place P&W's market share at 26 percent, GE's at 34 percent, with RR still at 21 percent and a host of newcomers at 19 percent. Clearly the loser in all this is P&W — their 28 percent drop in units shipped is seen in GE's 13 percent increase and the newcomers' increase of 15 percent.

Just who are these newcomers? They are France's SNECMA, the Japanese Aero Engines Corporation (JAE), Germany's Motoren-und-Turbinen-Union (MTU), and Italy's Fiat. The Japanese and European engine efforts have largely been the result of huge government subsidized consortia that spread the expense of research, development, and production. Most of these new entrants are in consortia relationships with other European or American companies, as in the case of the CFM56 and CF6 which are produced by CFMI. CFMI is a virtual company created by the partnering of SNECMA and GE. Both P&W and GE claim that the cost of developing a new engine design can exceed $1 billion; a staggering, technologically intensive investment that can take many years of successful production to pay off.

P&W and GE also compete with smaller companies such as Allison, Textron-Lycoming, and Garrett in the small engine market. This market includes small turbofan engines for executive jet aircraft, turboprop engines for light airplanes, and turboshaft engines for helicopters. With the expected decline in defense spending, civil engine sales become increasingly important for manufacturers. Due to the extremely high cost of market entry and current overcapacity, it is unlikely that any additional major domestic competitors will emerge to challenge GE and P&W.

### Helicopter Industry

With four large domestic and four large foreign manufacturers, the helicopter industry is also burdened with gross overcapacity. This overcapacity doesn't even begin to address the vast Russian vertical lift capability that has not yet entered the market place.

The U.S. helicopter industry is an oligopoly. Currently, the rotary wing industry has approximately ten companies participating in the market place, with the top four being:

- Bell Helicopter Textron (small to medium aircraft)
- Boeing Helicopter (large aircraft)
- McDonnell Douglas Helicopter Co. (small to medium)
- Sikorsky Aircraft (United Technologies)(medium to large)

The helicopter industry has five other competitors for civilian markets: Enstrom Helicopter Corp., Rogerson Hiller Corp., Hymes Aviation Industries, Robinson Helicopter, Inc., and Schweizer Aircraft Corp. The majority of these companies are pursuing the piston-engine market. As of February 1992 it was forecasted that Robinson, Schweizer and Enstrom will control the piston market by 1997.

The foreign market is also oligopolistic and dominated by Aerospatiale, Westland, Agusta, and Messerschmitt-Boelkow-Blohm (MBB). Aerospatiale of France and MBB of Germany have merged their helicopter units to form Eurocopter in hopes of controlling the helicopter industry. Westland and Agusta have also collaborated as EH Industries, building the EH-101. Most foreign companies have the support of their governments. The foreign governments' strategy is a long term approach to funding and an attempt to align the aircraft industry procurement to support their national industrial policies.

The market cannot sustain this many manufacturers; consequently, all of these companies are partnering in hopes of strengthening their position in order to survive.

The military market historically has dominated the helicopter industry. Centered around supporting off-shore oil exploration and drilling, the civilian helicopter market grew dramatically through the 1980's but has come to a grinding halt during the 1990s. Future civilian market concentrations appear to be in the areas of police work and emergency medical service.

Funding for all the services' helicopter programs in the 1992 military budget was $5.5 billion, with $2.2B in procurement, $1.6B in modifications and modernization, and $1.7B in research and development. Current estimates are that future budgets will lean toward R&D funding. The tremendous cost associated with technology and prototype development have forced competitors to team together to compete for major Department of Defense (DoD) programs. In addition to the cost associated with entering the market, the bureaucracy and massive oversight requirements of the largest buyer, the DoD greatly complicate the industry's performance.

## CONDUCT OF THE INDUSTRY

The conduct of the American aircraft industry is shaped by the defense drawdown and associated indirect military subsidies; stagnant world commercial markets; reduced after-market sales; and finally, the external challenge by the Airbus consortium.

## BUYING POLICIES OF CONSUMERS: COMMERCIAL AND GOVERNMENT

### Commercial Airlines

Aircraft demand is a derived function of the consumer — airlines are a service industry. Airlines seek to maximize long-run profits by optimizing aircraft selection to their route system. Aircraft alternatives — new and used — are characterized by different ranges, sizes, fuel efficiency, maintenance costs, and flight crew size. Carriers evaluate aircraft options in their projected route structure by estimating fares, passenger load, fuel costs, and financing rates. There is a major tradeoff between capital and operating costs. Fuel accounts for approximately 56 percent of lifecycle costs, aircraft purchase price — 14 percent, with the remainder in maintenance, financing, and direct flying hour costs. The maximum amount an airline is willing to pay for any aircraft is equal to the net present value (NPV) of the expected dollar stream contribution discounted using the firm's marginal cost of capital.

***Airline Deregulation and Bankruptcy.*** Estimating any future dollar stream for airline operations has been extremely difficult since airline deregulation occurred and extended operations under Chapter 11. Since airline deregulation, fare prices have oscillated wildly and ruinous price-cutting by any firm must be matched by all in this oligopoly sized industry. U.S. airlines have lost $10 billion in the last three years. The poor financial shape of the airlines has most often been blamed on deregulation. We believe the fault lies more with a combination of poor management, inefficiencies, leveraged buy-outs, and prolonged operation of failed carriers under the protection of bankruptcy laws. Airline long-term forecasts were grossly optimistic in the 80's, leading to overbuying, high debt, and a lack of available investment resources.

Recently, three large airlines were in Chapter 11 bankruptcy reorganization: Continental, TWA, and America West. (Continental just came out). Many argue that airlines allowed to stay for an extended time in Chapter 11 gain advantages over competitors. While in Chapter 11, debt obligations are postponed as they reorganize under the supervision of a federal judge. Meanwhile, non-bankrupt competitors have to pay their debts. Aggressive pricing, frequent flyer programs, and alternate service offerings have to be matched by competing firms. The result is fewer aircraft buyers and severe supplier overcapacity for the diminished demand. There has also been an industry trend toward U.S.-foreign partnerships to avoid bankruptcy.

***Advantages of Product Families.*** A product family from one basic airframe and engine supplier can provide substantial savings in aircrew and maintenance training costs, reduced and shared spares inventory, and efficiency in reliable supplier relationships developed over years. Aircraft sales have separate prices for airframe, engines, and avionics options. Engine selection may account for 50 percent of lifecycle costs, even though it is only 20 percent of the original purchase price. Engines contain the preponderance of high-stressed parts subject to wearout. However, reliability and maintainability (R&M) improvements in engines have reduced after-market sales and support. With engine options, air carriers can achieve engine commonality across different aircraft types.

***Financing Arrangements.*** During this period of slack demand, terms of sales

agreements are increasingly important. Export credit financing has become *less* important in the Airbus challenge since 1985 when the Organization for Economic Cooperation and Development (OECD) adopted Large Aircraft Sector Understanding (LASU) allowing for loans of 10-12 years at rates based on the U.S. Treasury bond yield. However, there are many other areas lacking such discipline. Sales arrangements can be appreciably made more attractive by:

- Altering the progress payment schedule to decrease NPV net present value) cost.
- Performance and warranty guarantees for fuel efficiency, maintenance man-hours per flight hour, etc.
- Discounts on "white tail" aircraft built to keep production lines open during times of slack demand (only affordable by government financing for Airbus).
- "Walk away" leases for airlines forgiving normal termination charges.
- Counter-trade assistance for trade-in aircraft from the carrier when they buy new replacements.
- Manufacturing offsets for local work content from the buyer nation's industries.
- Barter arrangements accepting market goods when offsets aren't found.

***Other Inducements.*** It is difficult to document and quantify the impact of political inducements on buyer's decisions. European landing rights and additional landing slots have been offered to foreign air carriers purchasing Airbus planes. (The '92 U.S.-EC Bilateral Agreement prohibits government conferring special favors in exchange for aircraft purchases.) The U.S. has offered inducements but primarily for military purchases to achieve interoperability with allies (buyers).

**Government Purchasing**

With the change of administrations, the economy in disarray, and defense industries already squeezed by President Bush's cutbacks, the FY93 and FY94 Defense budgets were trimmed, but there have been few major reductions. The FY94 budget — $263 billion in budget authority and $277 billion in outlays (actual spending) — kills no major weapons program, makes modest personnel reductions, and defers most tough decision about the size and shape of the post-Cold War military until the next full budget round. The higher outlay figure reflects efforts to complete weapons programs in production but suggests future reductions.

***Savings?*** The largest "savings" — $5.8 billion — come out of procurement accounts, achieved mostly by scaling back weapons purchases or slipping production schedules. The FY 94 budget proposal includes more than $8 billion in R&D funds for many tactical aircraft/helicopter programs such as:

- F-16 and F-22 fighters
- FA-18 C/D fighter
- A/FX deep-strike Navy bomber
- FA-18 E/F multi-role fighter
- F-14 upgrades

- V-22 tilt-rotor
- SH/UH-60 helicopters
- RAH-66 Comanche helicopter.

Although each program has individual merit, it is unlikely that any Congressional budget resolution will afford them all.

Promising to continue all programs may raise false hopes for Defense contractors. Hard decisions have to be made and it may be wise to "cull the herd" so that those remaining can have a profitable existence. We must avoid extending program schedules and reducing quantities after contractors have invested in production capabilities — it's unprofitable.

***Contractor Forecasts.*** How should defense contractors forecast the future?

- The government may continue laissez-faire policies during the downturn.
- Global defense markets are shrinking or technology restraints and export controls hamper sales.
- Commercial applications of defense technology haven't worked.
- Moving away from core competencies invites failure.

***What are possible contractor responses?*** Facing survival problems, company options are to strip down, shut down, sell, swap, or spin off units of the company in order to salvage the profitable from the unprofitable. This would collapse the excess overhead. However, will the sub-tier vendors survive? Will the segregated units of the company retain the "critical mass" to accomplish the complex, integrated functions of Defense work? The U.S. government has made a commitment to preserve design/integration teams, evidenced by the rough budget parity of R&D and procurement funds. However, R&D put on the shelf does not constitute production readiness. The transition from development to production represents a complex interaction of design, test, and initial production. By remaining in R&D phases and not awarding production contracts, the work force skills and capability to successfully transform from designs to military power are jeopardized.

***Government reliance on arsenals?*** The combined depot/arsenal system for all military equipment has a $13 billion annual budget. Over 33,000 aircraft are kept in service with 44 million direct labor hours. However, newer aircraft are more reliable, requiring less maintenance. In the future, fewer aircraft and less work for remaining aircraft yield excess depot capacity. To eliminate service duplication and forecasting the reduced future workload, the service departments scrutinized their depot maintenance capacity. In a 15 January 1993 memorandum to the Deputy Secretary of Defense, the service secretaries stated 14.6 million direct labor hours (3M for rotary, 11.6M fixed wing aircraft) are excess to requirements. They suggested four aviation depot equivalents could be closed. This downsizing would not "help" industry — it would merely keep capacity for current government share.

***Fair Competition? Efficient Operations?*** "Publicly owned defense facilities are approximately 30 percent less efficient than their private counterparts". Does that condemn civil service or does it mean arsenals have taken on "ash and trash" jobs that could not be operated profitably? It is hard to provide incentives to monopoly activity — public or private.

How can we encourage competition, retool with modern, flexible equipment, and still use the arsenals for non-profitable requirements? GOCOs (Government Owned, Contractor Operated) depots have been suggested to combine government long-term investment in facilities with flexible private-sector operation.

The government could compete the management of arsenals and modernize tooling for efficient operations. Choosing a GOCO vs. private firm should be a function of three variables:

(1) Government funds already invested in the depot for weapon system support.
(2) Life expectancy or life remaining of the end item.
(3) Technology cycle for the system.

Systems with a high demand function (low government investment, long life remaining, and rapid technology turnover) would favor commercial support over GOCO/depot responsibility.

**Commercial Selling Policies and Production Practices**

***Economics of Production.*** High sunk costs, learning curve effects, and scale economies of production not only limit the competitors in the field but reduce innovation and encourage derivatives. This is especially true when a firm lacks capital. A competitor with capital can then exploit this lack of technical change (e.g., Airbus in early '80s).

To launch a new aircraft, a producer needs to target a "hole" in the market — an area of growing demand not well served in terms of aircraft range and size by existing aircraft. Building a new airliner can cost between $2-4 billion for development, tooling and certification. Planes are priced on the basis of average expected cost for an initial production batch of 400-600 units. First units are sold at a loss since the learning curve has not reached expected average cost and may not reach a positive cash flow until about the 70$^{th}$ unit. This lag for initial production may require an added $2 billion "launch" investment.

Thus a firm may have to "bet the company" to launch a new airplane, meaning negative cash flows for the years of research, development, and early production (totaling $4-6 billion) exceed the net worth of the company. Even derivatives of existing aircraft can cost more than a half-billion dollars to develop and certify.

***A Family of Aircraft.*** Varying the size and range of a product can tailor a plane to optimize costs over different route structures. Not only do buyers enjoy training, spares, and maintenance commonality but producers can use common parts and assembly requirements for efficient manufacture and assembly of different aircraft. For example, the Boeing 707, 737, and 757 all share the same basic fuselage design. This commonality also exists with the Airbus A330 and A340.

Average production costs decline due to continued learning curve benefits, use of existing plant and managerial capacities, and simplified after-sales support for derivatives 'pooling' common items. Consequently, winning first orders is crucial since it can lead to

long-term commitments to a product family.

***Technical Innovation.*** Incremental modifications can be economically important. Airframer's $4-6 billion up-front expenditure is spent on <u>integrating</u> technologies (materials, propulsion, aerodynamics, avionics, etc.) rather than <u>developing</u> break-though concepts from inception. For U.S. suppliers, technology has to "buy its way" onto the aircraft, meaning the addition will positively benefit customer operations in their route structure (reduce cost, improve safety, comply with regulations, etc). To show that they had a new airplane, the Airbus A320 introduced several new technologies such as variable camber wings, active fly-by-wire controls, digital autoflight systems, sidestick controllers, and composite materials. The technical risk of fly-by-wire was affordable since Airbus governments provided performance and warranty guarantees. While the U.S. advantage remains in large scale system integration, Airbus and U.S. firms are technologically equal.

**Sharing Risks.** Antitrust laws make it easier for U.S. firms to cooperate with an overseas rival than an American competitor. An outstanding example is the General Electric partnership with France's SNECMA for turbo-fan engines. Pratt and Whitney is excluded from production partnering with GE while a foreign firm reaps technology infusion and profits. McDonnell Douglas sought a 40 percent equity share with Taiwan that it needed to launch the MD-12. Boeing engaged three Japanese firms to build 20 percent of the Boeing 777 with shared development costs. Boeing's alliance with Japan could preempt Airbus or McDonnell Douglas. Recently Boeing has negotiated with Airbus' individual members to cooperatively build a double-deck jumbo aircraft. This tactic could not only co-opt Airbus, but it could also delay the consortium's efforts, allowing Boeing time to finish their 777 and prevent competition for their 747.

Boeing and McDonnell Douglas exported 70 percent of their combined output in the first half of 1992; export sales remain healthier than domestic markets and sharing risks serves as a market avenue. They do not want to jeopardize these "door-opening" partnerships by the U.S. government aggressively pursing "fair trade" (read: protectionism!).

**Management Practices**

***Overcapacity.*** With both defense and commercial markets simultaneously in downturns, management must deal with the worldwide excess capacity in all sectors. The Defense sector will have to restructure; the commercial firms will try to stay viable until the end of this decade when markets should improve. Management practices include: paring down to core businesses; conversion; foreign military sales; total quality management; strategic partnering; and financing sales.

***Defense.*** Reduced budget outlays from prior year obligations are only now being realized. Companies are completing backlogs and relying on near-term contracts to survive. Management options are to strip down, shut down, sell, swap, or spin off units of the company in order to salvage the profitable from the unprofitable. To survive, management must reduce costs faster than budget outlays decline (approximately 7 percent annually). Management decisions are a function of competitive dominance and attractiveness of the market segment. This may explain General Dynamic's decision to sell its jet fighter unit. They found

themselves operating in a sector where they were not the number one or two contractor (lack of competitive dominance).

***TQM/Strategic Partnering.*** To maintain a "critical mass" in this downsizing, companies have teamed not just to share cost risk, but to become strategic partners and take advantage of distinctive quality competencies. Northrop may become a subcontractor in the future. Prime contractors are downsizing suppliers from thousands to a network of a few hundred, connected electronically and sharing computer designs in CATIA or ISOGRAOPHICS format. Quality suppliers sharing demand data and designs to the maximum extent practicable will reduce real costs.

***Conversion*** of defense industries to produce something outside their core competence is not promising. Transferring public sector technology to private firms to generate commercial enterprises has only been 18 percent successful. Conversion of company assets into demand sectors and training of workers for jobs in demand make sense. Rather than a reconstitution policy to preserve former products and processes, a defense fusion policy encouraging flexible, agile manufacturing seems appropriate.

***Prototyping*** reflects the government initiative to retain design teams when production contracts are scarce. R&D funding will be nearly equal to procurement funds. McDonnell Douglas' new "Phantom Works" and Lockheed's "Skunk Works" will offer lower cost prototyping and development of new manufacturing techniques.

***Commercial.*** U.S. firms have to be conservative with a flat market projection. However, Boeing evidences a stronger commitment to future commercial business while McDonnell Douglas is stronger in defense. Boeing's activities such as the 777 deals with Japan, jumbo jet agreements with the individual companies of Airbus, workforce reductions, reducing the 747 production rate in thin times, and maintaining capital investment all indicate aggressive positioning for the future. In contrast to Boeing's investment and growth for the 777, McDonnell Douglas has not launched the MD-12. Until they can find an equity partner, McDonnell Douglas seems to be focusing on strategic partnering with 6-10 key airline customers, avoiding questionable sales and risky financing, and continued heavy cost-cutting in operations.

***Financing.*** Due to the financial stress of both the airline industry and the financial sector, aircraft manufacturers will find it increasingly necessary over the next three to five years to provide financing to their airline customers. Manufacturers who do not offer this financing are likely to find that the airlines will go elsewhere to buy aircraft. Only about 60 percent of the airlines enjoy investment-grade credit ratings.

Secondly, financial institutions have suffered significant losses due to both world economic and specific portfolio problems. Financing aircraft manufacture will be increasingly costly and financing sales will be increasingly risky. The conservative approach is a reasonable response.[1]

**Capital Investment.** Company actions follow the aforementioned trends. Boeing's '92 investments in building/fixtures were up 20 percent, machine/equipment up 10 percent,

and construction in-progress up 39 percent. While McDonnell Douglas' building/fixtures were up 2 percent, their machine/equipment segment was down 24 percent.

***Labor Practices.*** Both companies are unionized although McDonnell Douglas' Long Beach operations in Southern California require a higher benefit burden. Both companies have significantly reduced their workforce and do not plan to add to the rolls until orders return. There is an increasing use of temporary personnel for services not specific to aircraft manufacture — such as janitorial service, cafeteria, security, etc. This avoids extending union benefits to all.

**Government Intervention**

There is a distinct preference for either increased government role or continued laissez-faire policies depending on the firm's export position. Those with an overseas market share don't want an interventionist government prompting a trade war. Those firms with principally domestic/military markets want increased opportunity to sell abroad and increased access to compete for U.S. public sector functions — federal labs and depot maintenance in government arsenals.

***Commercial Export Sales Opportunity.*** Due to the extreme market condition, commercial manufacturers are pressing for permission to sell to countries not favored by the U.S.. Iran has expressed interest in buying as many as 20 Boeing 737 jets with GE engines — total value of $750 million, but the sale is being blocked by U.S. trade restrictions. Enforcing these political restrictions hurts our sub-tier industries. Denying these items as potential "dual use" weapons seems specious considering the Desert Storm experience with Iraq. However, dealing with a rogue nation like Iran with a history of terrorist support deserves careful review. Unfortunately, Airbus will sell regardless of Iran's policies and the U.S. cannot stop them since the U.S. content of Airbus is below 10 percent — stripping the U.S. of veto power. A similar — though less drastic — situation can occur with China in the aftermath of Tiananmen Square. Boeing is in a strong position in China but could lose to Airbus due to comparable political posturing.

***Arms Sales.*** The U.S. has significant excess inventory of military hardware that could be given to friendly nations and used to gain future base access and interoperability. However, manufacturing firms could lose sales as we dispose of surplus systems. Manufacturers are asking to sell more advanced weapons knowing that Europe, Russia, or China will meet the demand if we don't. A denial by the U.S. does not stop the technology diffusion. Finally, the terms of defense trade have been under review. U.S. firms have suggested government financing similar to the U.S. Export-Import Bank be available for legitimate foreign defense needs. They propose forgiving recoupment of development costs to be more competitive, and control of the offset requirements by foreign countries so we don't lose sub-tier jobs overseas.

***Public/Private Sector Competition.*** In order to maintain "critical mass" in an era of less procurement, industry has requested that modification and maintenance jobs performed by public arsenals be considered for fair competition. The argument is that public jobs should not be inviolate while private jobs are lost. Fair, comparable pricing for "a level playing field"

and political strength associated with permanent infrastructure are substantial issues. Decisions for public vs. private should consider:

(1) The amount of support already invested in the U.S. depot.
(2) The number of aircraft and major systems involved.
(3) The expected life remaining.
(4) Rate of technology turnover.

Since the industry is already in overcapacity, we should not encourage more redundancy. However, commercial efficiency combined with government help could be achieved through a GOCO arrangement with commercial management competed on a multi-year basis.

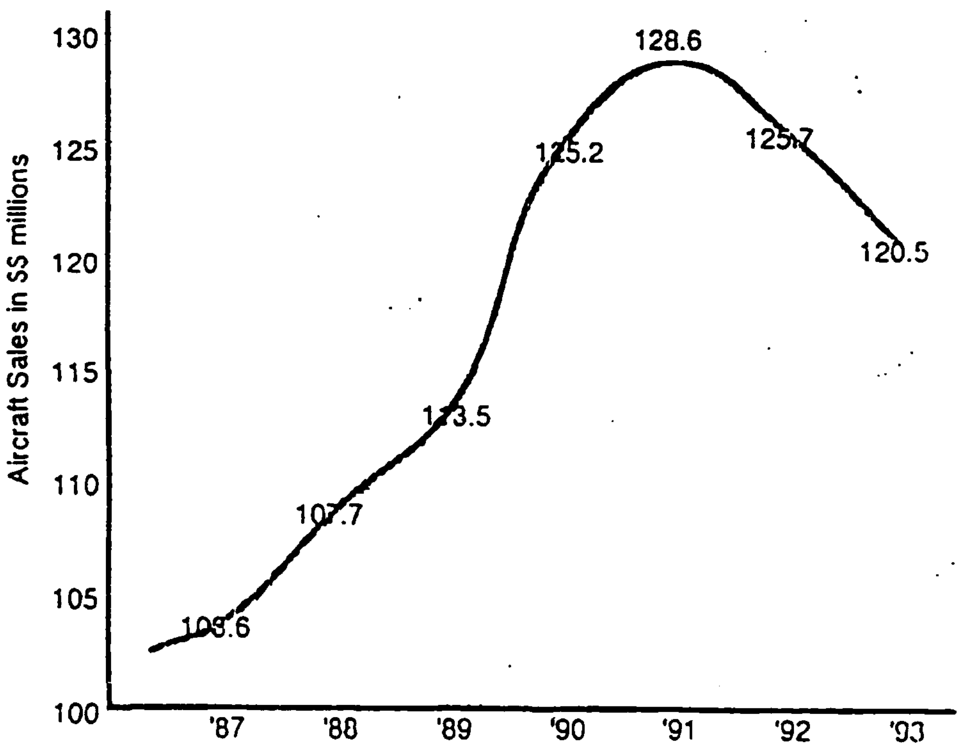
## INDUSTRY PERFORMANCE

### General

As the world's leader in the aircraft industry, the United States has experienced decades of unparalled success with very little foreign competition. Recent years have seen changes in the industry as it faces increasing worldwide competition.

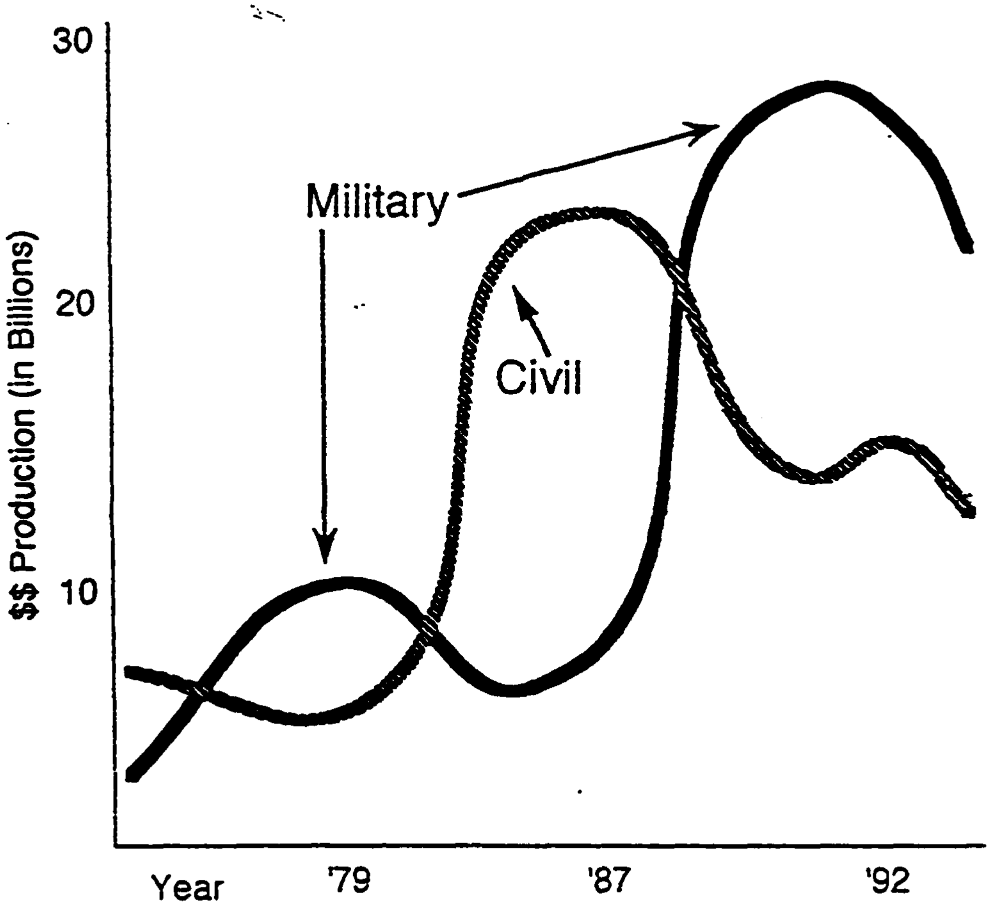
Currently reduced by defense cuts, global economic weakness and strong competition, the U.S. aircraft industry will experience declining sales for the third straight year. This downturn of the market is showing up on the balance sheets (Fig. 2).

**Figure 2. Aircraft Sales**[2]



With reduced sales, firms must improve productivity to eke out any profits. In the past the civilian aircraft market helped sustain a declining defense market. This time the civil sector faces the cumulative effect of the worldwide economic downturn (Fig. 3).

**Figure 3. Military/Civilian Aircraft Production Cycles**




With a further reduction in passenger traffic and airline finances weak, aircraft and parts orders during 1993 should be well below the boom that occurred in the late 1980s. The Aerospace Industries Association predicts that in 1993, aircraft sales will fall $3 billion in the military sector and $3.6 billion in the civilian aircraft market[3].

## Civil Aircraft

We see a distinct difference in level of investment by the U.S. firms. Boeing is building for the future. McDonnell Douglas can't afford to. Boeing has been the only profitable commercial aircraft producer in the last twenty years.[4] Companies are improving cycle time by implementing new manufacturing processes and achieving reduced work in-process inventories.

The combined backlog of McDonnell Douglas and Boeing was $106 billion at the end of June 1992, down five percent from June 1991. The Airbus Consortium continues to increase its share of the commercial aircraft industry. This keen competitor is increasing its production and introducing three new models — the A321, A330 and A340. This increased production will cut even further into future McDonnell Douglas and Boeing sales, forcing both to reduce their production. Both companies have already significantly reduced employment. While imports have been increasing — primarily due to Airbus influence — the aircraft industry remains the United States' largest net exporter with over $30 billion.

To survive, the aircraft industry will focus on three overall strategies: restructuring or resizing the company, conversion to making a different product, or staying in the business but improving competitiveness in the worldwide marketplace. Each strategy requires significant modification to previous business practices.

This segment will see continued long term growth. The International Civil Aviation Organization forecasts worldwide airline traffic growth of 5 percent in 1993 and 6.5 percent in 1994. Growth will be principally overseas — especially in Asia[5].

## Military Aircraft

The worldwide decline in defense spending has had a significant impact on the sale of military aircraft. Demand for U.S. military aircraft has been declining since 1987; U.S. manufacturers expect to ship 600 aircraft in 1993 — half the number shipped in 1987. Historically, the U.S. procured 80 percent of military aircraft sales. The Foreign Military Sales (FMS) program of the Department of Defense (DoD) represented the 20 percent balance.

While procurement of aircraft has declined significantly, research and development (R&D) funding has continued. This funding will allow some aircraft development to continue. Investment in R&D is critical to the long-term survival of our aircraft industry. Foreign companies reinvest as much as 25 percent of their profits into R&D. In addition, those foreign companies that are government-owned are under no obligations to stockholders. On the other hand, U.S. corporations and private foreign companies invest no more than 12 percent of profits in R&D. To make matters worse, government support for R&D has recently declined from 60 percent to 40 percent. These factors lead to a great disparity between the relative commitment to R&D of private U.S. and government-owned foreign aircraft manufacturers. With R&D as the lifeblood of future competitiveness, this trend must be reversed if U.S. companies are to remain viable.

### Helicopters

Modest growth is anticipated in helicopter sales for 1993. Piston helicopter manufacturers saw a disappointing year in 1992, after six straight years of growth. Piston-powered helicopters accounted for almost 90 percent of all U.S. unit shipments in 1991. International markets were a significant source in 1992 but the worldwide economic instability slowed this growth. Recovery of both the domestic and international market is anticipated in 1993.

Exports and new products are sustaining the helicopter market. The new McDonnell Douglas MC520N NOTAR helicopter is successfully serving expanding operations for oil and gas exploration and production overseas. Continued growth is anticipated in 1993[6].

Deferrals or cancellations of aircraft deliveries have affected both commercial and military engine orders. The worldwide backlog of orders for civil turbofan engines stood at 5,800 at the beginning of 1992, but declining production rates at Boeing and McDonnell Douglas will stretch that backlog out several years. The backlog of U.S. military engines was 2,800 at the beginning of 1992, down 7 percent from 1991.

Manufacturers of aircraft structures, systems, and components face the same decline. More than 60 percent of the value of each U.S. aircraft is produced by subcontractors. The aircraft industry spare parts market is also in a downward direction. Consolidation of many military oriented suppliers has led to further unemployment. Aircraft parts suppliers also face increased competition from foreign buyers who require offset arrangements.

International cooperation with U.S. engine manufacturers teaming with previously foreign competitors has led to intertwining arrangements. For example, General Electric's collaboration with SNECMA of France on the manufacture of aircraft engines has been beneficial to both companies and good for the industry as a whole. Anti-trust laws have prevented the two U.S. engine companies from teaming arrangements but a propulsion research program has now been established with a waiver from the Department of Justice.

### Employment

Unemployment is the ultimate result of the defense spending reductions. Defense firms have cut hundreds of thousands of jobs over the past five years. The commercial aviation sector absorbed some of these personnel losses prior to 1990 but, as we have stated, that market is also now in decline and rapidly reducing its employment.

In 1992, no sector of the industry was spared from employment cuts. The civil aircraft sector experienced the largest reduction, cutting its workforce by 38,000 or 11 percent. Employment in the military aircraft sector fell 21,000 following a 45,000 cut in the workforce in 1991. In 1993 employment will continue to decline with the civil aircraft sector experiencing the smallest share of job cuts. The military aircraft sector is expected to lose an additional 14,000 jobs in 1993. Preferably, productivity increases are achieved through employee training and application of new technology, resulting in higher output per worker. However, it is unfortunately also increased by a reduced labor force, represented by the thousands of

skilled aerospace workers that have been laid off since 1989. With the flat market forecast, these people will most likely remain structurally unemployed.

### Profits

Net profits in both 1991 and 1992 were significantly reduced compared to prior years because of extraordinarily large non-operating expenses. The two primary causes are restructuring related to defense downsizing and the implementation of a Financial Accounting Standards Board requirement to reflect costs of employee post-retirement benefits other than pensions.

## INDUSTRY OPTIONS

As noted earlier, the American aircraft industry is a critical part of the U.S. economy. It must remain healthy in the future to continue providing the jobs and economic benefits that have been a mainstay in the past. To ensure continued survival, and to retain a competitive edge in the ever-increasing competition of the world market, the following items must be incorporated into future operations:

- Improve strategic planning — emphasize core values
- Streamline operations and existing production technology
- Continue R&D emphasis on process technology for high-quality products in minimum time
- Increase collaboration in the global market
- Stabilize relationships with suppliers
- Preserve design teams
- Emphasize flexible manufacturing

Each of these policies is discussed in the following sections.

### Improve Strategic Planning — Emphasize Core Values

The companies making up the industry must look at their goals and determine their core strengths and weaknesses. Are their product lines truly viable in the short and long-terms? Are their future plans realistic and do they take into consideration the changing world environment? For example, in light of the reduced defense spending, is it wise for a company to continue producing defense related products? Maybe it is time to start producing a product that is geared toward the civilian market. Or maybe a shift to a product line that has military as well as civilian application is in order.

Conversion to a dual-use product may not be easy, but it may be the best way to survive in the future. Perhaps some companies may decide to leave the defense business altogether. In any case, it's this type of long-range, strategic thinking and planning that will have to be done by every company in the aircraft and engine industry to ensure they stay competitive.

### Streamline Operations and Existing Production Techniques

This will provide immediate positive benefits needed to increase productivity. However, long-term productivity must include continued emphasis on Total Quality Management (TQM) and expanded education and training opportunities for the work force. Investment in a high-caliber work force through the empowerment process of TQM and increased job-related skills of education programs will pay dividends in overall increases to productivity and competitiveness of the aircraft work force in the future.

### Continue R&D Emphasis on Process Technology for High Quality Products in Minimum Time

The R&D effort must continue to proceed with particular emphasis on integrating advanced technologies into new product lines — investment for the future. Getting the high quality products to market in minimum time will require that manufacturing considerations become a more integral part of the R&D process. More than ever, engineering designers and manufacturing planners will have to work together from the very start of a product's development.

A prominent feature in the R&D process is the collaboration among domestic and foreign companies. Not only does it promote sharing technical expertise and reducing the cost risks associated with product development, but it provides an avenue for entering a new market. As companies try to gain market access and take advantage of other collaboration benefits, R&D will take on more of a "joint effort" feel and should provide a better product for the global market.

### Increase Collaboration in the World Market

Collaboration, joint ventures, and other partnerships will inevitably mark the trends for the future — if for no other reason than to gain market access. Of course, like R&D, the benefits of shared risk and obtaining information that a company may not otherwise be able to gain all help make collaboration an attractive option. Today, cooperation is essential to economic survival. Companies must take this new reality into account and work to establish ties with companies that are leaders in their field or prime players in their respective regions. New market opportunities in the Pacific Rim should not be missed, as well as other possibilities around the world. Western Europe, the former Soviet Union, and Eastern Europe all offer potential bright spots for future growth.

### Stabilize Relationships with Suppliers

The industry is suffering from overcapacity and needs to downsize. The fairest way to do this is to give market forces a free rein. Those suppliers who demonstrate consistent quality, pricing, and on-time delivery should be rewarded by getting increased business. Aerospace prime contractors should establish long term relationships with those subcontractors who prove that they are a "cut above." Noncompetitive subcontractors will be forced to leave the marketplace.

**Preserve Design Teams**

Design teams are a "national asset." In most cases, once they are broken up, they can never be reconstituted. For example, teams working on the design of stealth aircraft have no alternative outlet for their skills in the commercial sector. Only the Defense Department operates these specialized aircraft. Consequently, the preservation of these teams must remain a national priority. This is true of all defense-unique design teams. We cannot afford to let them disappear.

**Emphasize Flexible Manufacturing**

For many years economies of scale meant preeminence for United States manufacturing. Today the goal is to respond to unique customer requirements while still maintaining the low cost of large production runs. This can be done through flexible manufacturing. With the aid of computerized tooling, machines can turn out several unique items without slowing down production, all on the same assembly line.

## GOVERNMENT OPTIONS

The American aircraft industry is vital to both the economy and the defense of the United States. It should be saved; it must be saved. But it will require the assistance of the U.S. government.

What form of aid should be provided? There is no precise answer to this question because there are several methods of ensuring that the aircraft industry remains "healthy". Nevertheless, there are several viable policies the government should consider. These options can be grouped into three broad functional categories:

- Trade Policies
- Industrial Policies
- Acquisition Policies

Each of these policies is more fully discussed below.

**Trade Policies**

Trade policy options can be separated into three areas:

- Ensure Fair Trade
- Provide Political Support for Foreign Sales
- Expand Markets

***Ensure Fair Trade.*** The first trade policy the government should consider to assist the aircraft industry is to ensure fair trade practice by foreign nations. However, this requires the United States government to acknowledge that *American companies* are actually competing against *foreign governments.*[7]

Foreign governments are deeply involved in the financing of design, development, production, marketing, and sale of aircraft. They assume some or all of the financial, technological, and market risk associated with these endeavors. In parallel, they exert political pressures during the purchase of aircraft by their own and other airlines. Furthermore, they do not necessarily judge success or failure by the normal commercial standards of market acceptance and return on investment that apply to the U.S. private sector. Their criteria include national prestige, creation of an indigenous technology and production base, provision of employment and training of the work force, substitution for imports, evolution from a low-technology to a high-technology economy, and preservation of foreign currency.[8]

Moreover, the list of nations that assist their aircraft industries is a long one, including: Australia; Brazil; Canada; France; Great Britain; Indonesia; Italy; Korea; and Spain. Additionally, Japan also plans to be in the aircraft market by the year 2010.[9]

Clearly, no American firm has "pockets" that are deep enough to compete with a foreign nation, or the nations of the Airbus consortium. Accordingly, the government must take action — whether through GATT or some other mechanism — to "level the playing field". Moreover, the time has come to abandon the notion of *free trade* and insist on a world-wide policy of *fair trade.* Alternatively, if this policy fails, the United States government must assist the American aircraft industry as aggressively as other nations aid their aircraft manufacturers.

***Political Support for Foreign Sales.*** The second trade policy the government can and should take to aid the aircraft industry is actively promoting the sale of U.S. aircraft industry products abroad. Foreign sales — exports — improve our balance of trade, strengthen the domestic economy and provide jobs in the aircraft industry.

In order to help the industry, government does not need to be a partner with industry, merely a facilitator in the marketing process. The Commerce Department can more actively represent U.S. industrial capabilities when dealing with foreign governments. Modifying Export-Import Bank policies to permit more latitude in granting loans and financing terms will help make foreign sales more attractive to potential customers.

The United States government must recognize that foreign nations are actively involved in assisting their aircraft industry. It must, therefore, assist the American aircraft industry with overseas sales. To date, it has made some progress in this area, but it still needs to be more active in helping U.S. firms make sales in other nations.

***Expand Markets.*** The third trade beneficial policy is assisting the industry in expanding foreign markets. The Administration can ease trade restrictions with foreign nations, where appropriate, and do so in a timely fashion, which responds to the evolving new world order. Also, DOD and Commerce should continue to modify export controls and technology transfer policies that have outlived their usefulness or failed to keep pace with competitors' technological advancements.

**Industrial Policies**

The government can also pursue several industrial policies (note the plural to distinguish these options from the concept of one central, government-managed industrial policy which has no place in a free market economy). Among the alternatives the government can employ are:

- Continue R&D funding
- Create tax incentives
- Enact Aerotech legislation
- Modify anti-trust laws
- Establish a training partnership with industry

Each of these policies is more fully discussed below.

***Continue R&D Funding.*** A primary mechanism for assisting the industry is to increase the government's current level of R&D funding to NASA, but focus the additional funding on aeronautical applications. This will enable the nation to retain its position as the global leader in technology — and to use this advanced technology in military aircraft production if the need should arise. Indeed, the lengthy time it often takes to develop new technology, as well as apply it to a new system, makes it imperative that such technology be readily available if a changing world situation requires the production of new military aircraft.

It is a national security issue to continue R&D funding. The United States relies on the technological superiority of its military aircraft for success on the battlefield. In today's complex electronic/stealthy environment, the technologically superior aircraft has a much greater probability of completing its mission. This premise was confirmed during the air operations in Operation Desert Storm.

There are also other R&D policies the government can pursue to help the aircraft industry. It can, for instance, continue its efforts to support dual use technology (through ARPA), as well as expand U.S. process improvements through the manufacturing technologies program (MANTECH) and the industrial manufacturing improvement program (IMIP).

***Create Tax Incentives.*** A second industrial policy option available to help the aircraft industry is the creation of tax incentives. Under this program, the industry would be given a tax credit (not deduction) for R&D and the purchase of new equipment. It has the political benefit of not requiring any outlay of federal funds, thereby making it less likely to be challenged in Congress or the media. This program could also serve as a complement — or supplement — to the previously discussed policy of government funded R&D for NASA.

***Aerotech Legislation.*** A third possible industrial policy is to provide direct funding for R&D in the aircraft industry. This has been proposed in the "Aeronautical Technology Consortium Act of 1993" (S. 419, — the "Aerotech" bill), which is designed to promote "enhanced cooperation between the Federal Government and the United States commercial aircraft industry in aeronautical technology research...".[10] Under the provisions of this bill,

government and industry would form a partnership for technology research. However, the expenditure of *national* resources to support a *mature* aircraft industry would probably not yield an adequate return for this investment. Moreover, such an action could be construed as protectionist. Accordingly, this is probably not an option the government should pursue.

***Modify Anti-Trust Laws.*** A fourth industrial policy the government should consider is modifying its anti-trust laws. When originally enacted, U.S. anti-trust laws served a useful purpose in a primarily domestic market. However, the aircraft market is global, and when combined with the enormous expenses associated with developing and producing aircraft, existing U.S. anti-trust laws should be re-examined with consideration being given to today's competitive global market.

***Training Partnership with Industry.*** For a fifth industrial policy, the government and industry should consider becoming partners in training. Working together, government and the private sector can develop programs to retain displaced aerospace workers. In addition, as a result of downsizing, government resources and facilities are under utilized and should be made available to assist industry in improving the quality of continuing education and training for aircraft industry workers.

**Modify Acquisition Policies**

The third major policy the government can take to assist the aircraft industry is to change its acquisition policies. Indeed, acquisition policies have the greatest potential for near-term impact on the industry. If the government wants to maintain a viable aircraft industry, it must consider reforms such as: reducing oversight; curbing the growth of burdensome regulations; limiting contract changes and modifications; multi-year contract funding by Congress; and use of the Uniform Commercial Code and commercial standards whenever possible. Moreover, without taking action in some or all of these areas, the government may be contributing to the end of the American aircraft industry. There are also several other major acquisition policies available to the government.

First, today's adversarial relationship is not conducive to working for mutual benefit. Trust and confidence should characterize professional relationships. How risk is shared is often the key to success or failure. As a new business practice, the government should fully fund R&D efforts rather than expecting company investment that could be recouped during a production run.

Second, Secretary Aspin's "silver bullet" concept has merit. That is, substantial production runs will probably be the exception in the future, but the "silver bullet" option allows for the production of the exceptional technological breakthroughs — such as the F-117.

Third, without production contracts, aircraft industry firms will be trying to obtain modifications and maintenance contracts as a survival measure. It would seem, therefore, that the government should divide these contracts *equitably* between depots and the private sector in order to share the pain of declining markets.

**Summary**

The bottom line is that the U.S. government must provide assistance to our aircraft industry in order for it to maintain its preeminent position in the world marketplace. The government must increase R&D funding to NASA and/or provide tax credits to aircraft manufacturing companies to stimulate new technology advancements. It must acknowledge that American companies are competing against foreign firms and insist on fair trade policies and open markets. Moreover, it must aggressively help U.S. companies' attempts to make inroads in foreign markets. Finally, the government must take immediate action to reform the cumbersome DoD acquisition process. Without these measures, the U.S. aircraft industry may be in danger of losing its decades-long global leadership position.

## CONCLUSION

A healthy, robust aircraft industry is essential to the United States. As a vital defense industry, it provides the nation with the world's most technologically sophisticated aircraft, military and civilian — the best in the world. It is also a substantial, indeed critical, part of our economy. Employing nearly one million people, many of them scientists and engineers, the aircraft industry is the nation's leading exporter of manufactured goods. It is a leader in research and development, relentlessly pushing the frontiers of technological advancement. U.S. firms achieved this position of world leadership by combining a strategic vision with an entrepreneurial passion that led to a period of unparalleled growth and achievement.

"But the times they (have been) a'changin." No longer is U.S. supremacy unchallenged. State-of-the-art competitors such as Airbus, Rolls Royce, and SNECMA, often with unabashed government support, prevent American firms from resting on their laurels. U.S. industry has awakened to this global competition, and its strategic options for countering this surge, most of them already in force, have been discussed previously. But industry and government must work more closely together in the future — the near future — not through protectionism or oppressive "government industrial policy", but as partners mindful of the benefits which this country has derived, and will continue to derive, from a robust, world-class, aircraft industry.

Near term the industry will continue to experience a period of severe turbulence brought about by shrinking defense budgets, weak commercial markets, overcapacity, diminished aftermarket demand and intensified global competition. With industry options limited and government responses not yet formulated, the future may be uncertain. But one constant remains: the United States retains the capability to remain the leader in the global aircraft industry. Forward thinking — and cooperation — by industry and government are the keys to maintaining this leadership.

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# INDUSTRY STUDIES

# #9

# SPACE

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| | |
|---|---|
| Applied Physics Laboratory | Washington, DC |
| Defense Mapping Agency | Washington, DC |
| NASA Headquarters | Washington, DC |
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| McDonnell Douglas Corporation | Los Angeles, CA |

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|---|---|
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| French National Space Agency (CNES) | Paris, FR |
| European Propulsion Society (SEP) | Paris, FR |
| Aerospatiale Space Systems | Les Mureaux, FR |
| Aerospace Research Establishment (DLR) | Munich, GE |
| Deutches Aerospace (MBB) | Munich, GE |
| Dornier | Friedrichshafen, GE |
| British Aerospace Corp | London, UK |
| International Maritime Satellite Corp | London, UK |

In addition, one student visited Russia and met with various government and commercial officials in Moscow and St Petersburg.

## ABSTRACT


This report presents the results of research conducted by the 1993 Industrial College of the Armed Forces Space Industry Study (IS) Seminar. The purpose of the seminar was to determine the capabilities of the US Space Industry to satisfy US national security needs and successfully compete in the global marketplace. It is based on information from guest lecturers, individual and group research, visits to national and international governments and organizations, universities, laboratories, and private sector corporations. The report provides a background on the space industry, defines the key issues, and provides recommendations.

Although the US Space Industry is small compared to other defense industries -- employing about 167,000 people and accounting for less than one percent of the GNP -- space systems are essential to national security and are characterized by advanced technology.

The US satellite manufacturing infrastructure is healthy in terms of capital, plant, and technology. Nevertheless, it has substantial overcapacity resulting from decreased government spending. Ongoing corporate initiatives to downsize should compensate for reduced revenues.

The US expendable launch vehicle infrastructure is slowly recovering from a long period of neglect. These problems, combined with a diverse stable of aging launch vehicles that are often specially configured for each payload, result in long lead times for launch and difficulty in meeting processing schedules. These problems are magnified when U.S. launch capabilities are compared to those of the European Space Agency (ESA). The current series of Ariane 4 launch vehicles are impressive in terms of their low cost and schedule reliability. The follow-on Ariane 5 vehicle promises to improve on these factors.

We conclude that the US space program suffers from a failure to implement an integrated space policy which sets proper priorities. The US government should take the lead in international negotiations for economic "rules of the road" to prevent foreign domination and at the same time withdraw from its central role in domestic commercial space areas. Most importantly, the US is at a crossroads in space launch. It must either develop a viable launch infrastructure for the 21st century or lose world leadership in this vital security area.

We suggest further reduction of excess capacity in industry and more international cooperation in the future. We feel that many innovative approaches to international cooperation exist and should be looked at in all arenas of the space industry.

# INTRODUCTION

## Purpose and Scope

The purpose of this study was to evaluate the US Space Industry to determine its capabilities to satisfy national security needs and successfully compete in the global marketplace. The study included a look at US space launch systems, satellite systems, the supporting infrastructure as well as a segment of the international competition which faces the US Space Industry. The authors are military officers and government civilian executives from a variety of backgrounds comprising the ICAF 1993 Space Industry Study (IS) seminar. The conclusions and recommendations are based on individual study, classroom discussion, and both domestic and international visits with governmental and commercial organizations. The report is not intended to be comprehensive but rather focuses on those areas which the authors deemed necessary to provide an accurate evaluation. It begins with a discussion of US space policy and, specifically, why the space industry is important to US national security.

## Why Space Is Important to the US

The US delineated an overall policy for space in 1989 which identified six goals for the national space program to:

- Strengthen the security of the United States
- Obtain benefits for the general population and improve the quality of life on Earth
- Encourage private sector investment in space
- Promote international cooperative activities consistent with US national interests
- Cooperate with other nations in maintaining the freedom of space
- In the long term, expand human presence and activity beyond Earth orbit into the solar system

These goals were intended to be achieved through the three areas of space activity -- defense, civil, and commercial.

### *Defense*

The US defense establishment has used space for many years. However, prior to Desert Storm, there was a relatively small community who knew and understood the capabilities of space and how to use them. Desert Storm brought a much greater awareness of the tremendous force-multiplying effects of space-based assets. Space-based command and control capabilities, overhead intelligence collection and dissemination, world-wide communications, accurate weather assessments, pinpoint navigation, and highly accurate mapping all contributed to Desert Storm's success. The new awareness of space capabilities has caused increasing demands on space services for our own forces, but more importantly, our potential adversaries are now aware of the state of technology and are rushing to match or counter our capabilities.

### *Civil*

The civil sector of the industry, headed by NASA, has long been famous for spectacular space achievements. From the first manned space flights and Apollo lunar landings to the development of the world's first true spaceship, the Space Shuttle, these efforts provided several important research and development benefits to commercial industry -- in some cases spinning off whole industries (e.g. microelectronics). More recently, the US delineated several key objectives for the civil space effort to:

- expand knowledge of the earth
- create opportunities for use of the space environment
- develop technology for civil applications
- preserve preeminence in critical aspects of spacescience, applications, technology, and space flight
- establish a permanent, manned presence in space
- engage in international cooperative efforts that further overall US space goals

### *Commercial*

Despite its small relative size, space is big business. One estimate indicates that over $80 billion was invested in space worldwide in 1988. The commercial use of space is growing at an accelerating pace. Voice communication systems, entertainment systems, data collection and remote sensing using space assets are becoming more commonplace. The world market has also dramatically expanded as former communist countries and China are now looking to improve their communication infrastructures.

To better position the US commercial space industry, the US government has defined a space policy intended to promote a market-driven commercial space sector by minimizing regulation, buying commercial products and services where feasible, and not supplying products or services that could be commercially supplied unless national security or public safety dictated otherwise.

For many reasons, therefore, space is an area of vital concern to the US. To determine the capability of the US to exploit this critical environment and the effectiveness of the policies outlined above, it is necessary to first examine the structure of the US Space Industry within its global context.

## INDUSTRY STRUCTURE

### General Description

While the space industry has been described as a single entity, a better definition is that space is a capability supporting and supported by a number of industries. These include launch systems manufacturers and satellite manufacturers producing systems for remote sensing, telecommunications, navigation, defense, and scientific exploration. In addition, a varied infrastructure supports both the on-orbit and launch activities.

Even though space is a big business and growing, it still represents a small share of

the overall US economy. As depicted in Table 1, over the last decade it has grown from a third of one percent to a half of one percent of the GDP. Over the same period space spending has been the dominant portion of NASA's expenditures and a growing portion of the DOD's. *Figure* 1 compares the relative size of the NASA, DOD, and commercial space expenditures. DOD's share, starting from parity at the beginning of the decade, grew to prominence by mid-decade but flattened out while NASA continued steady growth.

U.S. Space Funding History
(Current $B)

| | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 est | 1993 est |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GDP | 2965 | 3125 | 3317 | 3697 | 3971 | 4220 | 4453 | 4810 | 5170 | 5460 | 5627 | 5865 | 6232 |
| DoD Total Outlays | 157.5 | 185.3 | 209.9 | 227.4 | 252.7 | 273.4 | 282.0 | 290.4 | 303.6 | 299.3 | 273.3 | 307.3 | 291.4 |
| DoD Space Outlays | 4.1 | 4.8 | 6.2 | 8.0 | 10.4 | 11.4 | 14.3 | 14.4 | 14.5 | 13.0 | 14.4 | -- | -- |
| NASA Total Outlays | 5.4 | 6.0 | 6.7 | 7.0 | 7.3 | 7.4 | 7.6 | 9.1 | 11.1 | 12.4 | 13.9 | 13.8 | 14.1 |
| NASA Space Outlays | 4.9 | 5.5 | 6.1 | 6.5 | 6.6 | 6.8 | 7.3 | 8.5 | 10.2 | 12.3 | 13.4 | -- | -- |
| Federal Total Space Outlays | 9.2 | 10.5 | 12.6 | 14.7 | 17.3 | 18.6 | 21.8 | 23.4 | 25.1 | 25.6 | 28.2 | -- | -- |
| Total Space Revenues | 9.4 | 10.5 | 13.9 | 16.3 | 18.6 | 20.1 | 22.3 | 24.3 | 25.3 | 26.4 | 28.7 | 31.8 | -- |
| Commercial Revenues | 0.7 | 0.2 | 1.5 | 1.1 | 1.5 | 2.0 | 1.9 | 1.8 | 2.7 | 3.4 | 4.4 | 5.0 | -- |
| Total Space Revenues as % GDP | .32% | .34% | .42% | .44% | .47% | .48% | .50% | .51% | .49% | .48% | .51% | .54% | -- |

Sources: AIA Aerospace Facts & Figures, 1992.
Statistical Abstract of the U.S., Commerce Dept 1992.

Table 1

By comparison, space-oriented activity in the private sector is a relatively small portion of the overall industrial base. With the exception of commercial satellites, the federal government largely dictates the direction and level of effort expended by US companies on space-related projects. With current downsizing in both defense and civilian space programs, the long term solvency of some major contractors comes into question. Without federal backing, companies are not willing to invest their limited assets in space research and technology that have uncertain payback potential. Instead they will seek other, more stable markets, or divest from space all together.

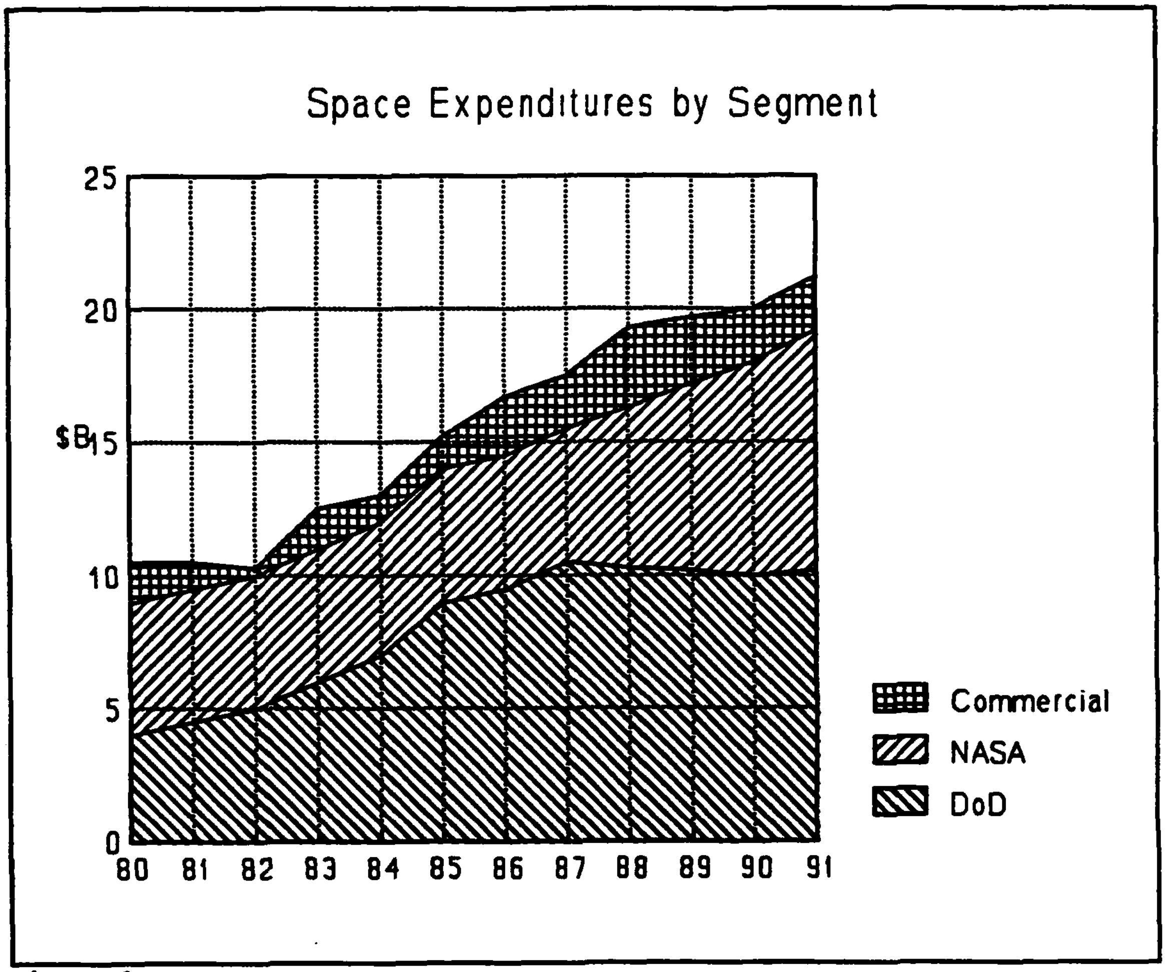


Figure 1

**Market Characteristics**

The small commercial business suggests that the overall space industry is structured as a monopsony, with the federal government as the single customer. Because a relatively small number of firms account for the business, we could describe the industry as a monopsonistic oligopoly. However, some uniqueness in the industry needs to be clarified.

The monopsony characterization is accurate only to the extent that NASA and DOD products are similar and the two agencies act as single buyer. However, each has different priorities and cultures when it comes to space. They compete for attention from the same pool of firms with wholly different agendas and methods.

In the commercial sector, the monopsony characterization breaks down. Commercial satellite buyers are diverse; the sellers are similarly so. Most industrialized countries have some participation in supplying components. Virtually all have the technological capability. The actual distribution of the work largely depends on corporate arrangements as a condition

of the [illegible] or two in their niche of the market.

The commercial launch sector is characterized by a few large firms operating independently (noncollusive oligopoly) with relative launch price stability and intense non-price competition (e.g. reliability, accuracy, etc.). This is attributed to the firms being reluctant to lower their prices for fear of sparking an industry-wide downturn in prices (with loss of revenue) and unwilling to raise their prices for fear of losing customers to the intense competition. As will be described later, this market structure could drastically change with the increasing non-market economic competition from the Russians or Chinese in the future.

The commercial use of space is growing at an incredible rate. As depicted in Figure 2, the commercial space sector generated an estimated $5 billion in revenues in 1992 with satellite communications goods and services comprising the lion's share of the market. This represents a growth rate of 14% for 1992 following a 29% increase in 1991!

The world market has also expanded as many former communist countries are looking to improve their communications infrastructure. New space technologies will allow them to move from antiquated systems to "high tech" in one step. Mobile land and aeronautical communications users, portable satellite receivers for mapping and surveying as well as remote sensing markets are expanding rapidly. However, as will be described next, there is some uncertainty in the commercial space market due in part to the very technology which has fueled the spectacular growth to date.

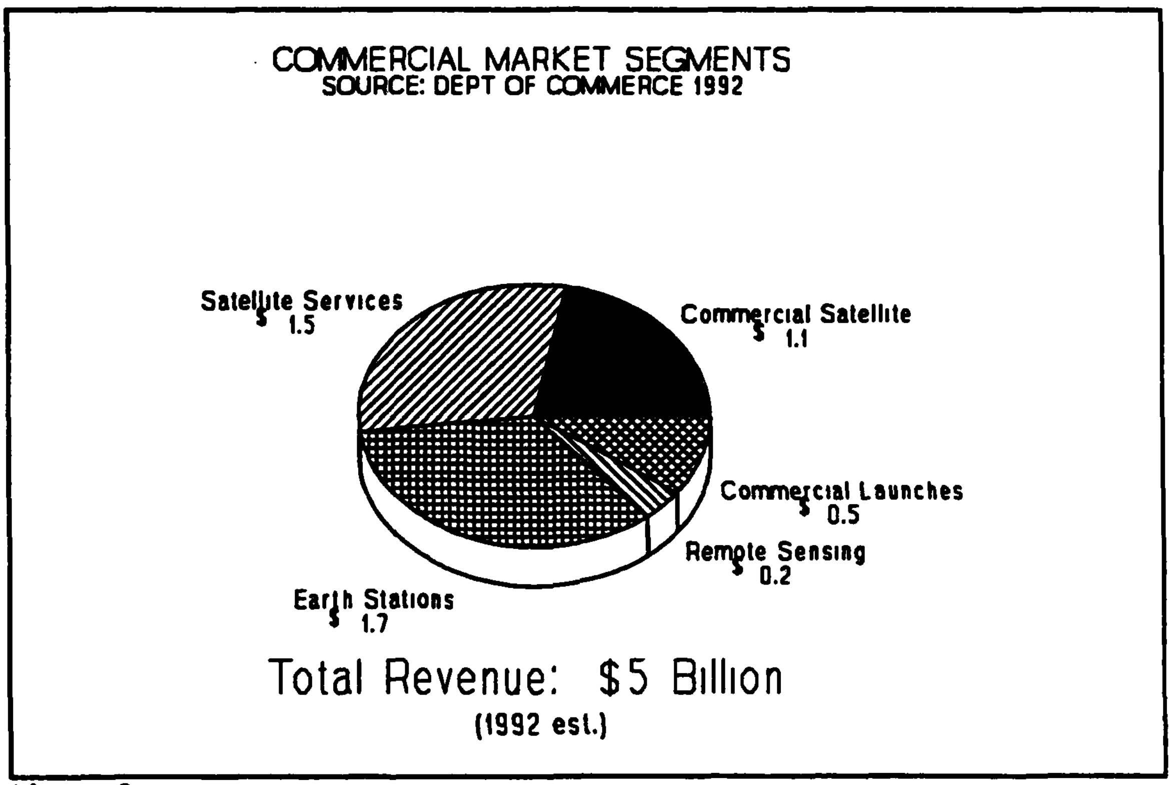


**Figure 2**

companies. Estimating the future demand for these services has proven to be uncertain for several reasons. Communications services comprise the largest segment of private space applications, making up 70% of the total satellite market. The requirement for communications satellite services is particularly affected by rapidly expanding technology and consumer demand. For example, the increased use of long distance fiber optic networks may reduce demand for satellite communications services while the convenience offered by worldwide personal telephone service technology may greatly expand it. Motorola's *Iridium* project, requiring more than 66 satellites in low earth orbit (LEO), is one example of this type of system.

The government demand consists of the civil sector (e.g. NASA, Department of Commerce, etc.) and national security (DOD, intelligence agencies, etc). In fact, as depicted in Figure 3 for communications satellites, the US government is the largest single buyer of launch services in the Western world. As a result, with all of its uncertainty in funding and policy priorities, the US government has a significant impact on the uncertainty of the launch services market.

In the face of this uncertainty, the demand for commercial launch services demand through the year 2000 is estimated to be 20-32 orbital launches per year, with the majority in the geosynchronous orbit (GEO) category. These do not include the US government's requirements, expected to be 22-37 per year, with half in the GEO and half in the LEO categories for the same time period. The projected requirements for commercial satellite launches, however, fall short of the world's capacity which will be described later in the report.

### Work Force

The reduction in defense funding has had a significant impact on the aerospace industry as a whole which suffered its largest decline since the aerospace recession in 1970. The number of people employed in the space sector (missiles and space systems) also declined. Employment averaged 192,000 for the past five years, but fell from a high of 200,000 workers in 1988 to 167,000 workers in 1991 (a decrease of 16%). The space industry workforce represents 14% of the aerospace industry employment or about one percent of the total employment in all US manufacturing industries.

In virtually all the U.S. space companies visited, representatives reported no difficulty in finding sufficient numbers of qualified individuals to hire (even before the recent downsizing). Most, however, did use internally developed, company specific training programs to qualify their work force after hiring. Nevertheless, several companies expressed serious concern over the long term ability to attract and keep top personnel if the downsizing continues.

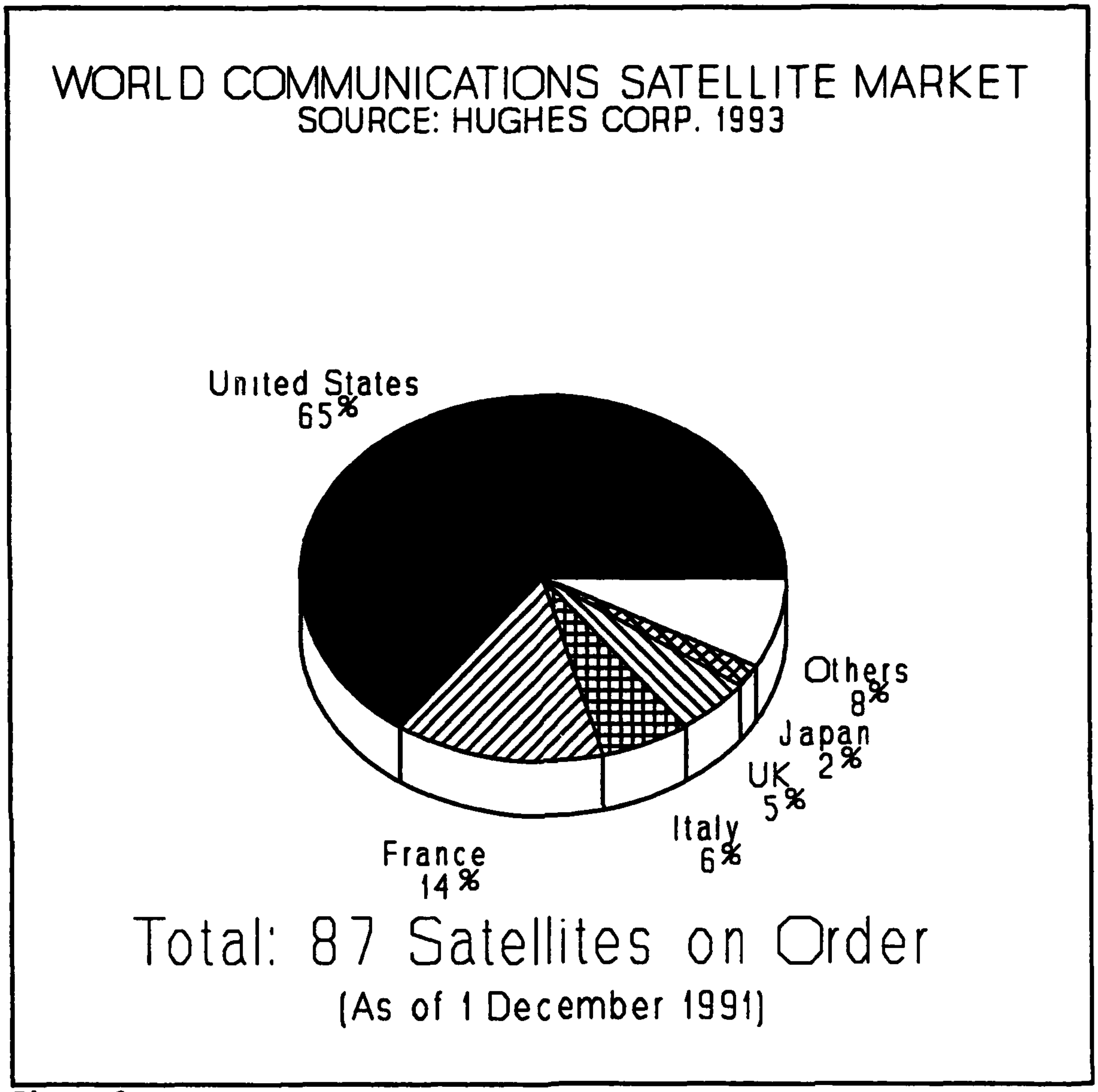
WORLD COMMUNICATIONS SATELLITE MARKET
SOURCE: HUGHES CORP. 1993
United States 65%
Others 8%
Japan 2%
UK 5%
Italy 6%
France 14%
Total: 87 Satellites on Order
(As of 1 December 1991)

**Figure 3**

## INDUSTRY PERFORMANCE

### General

The US space industry will most likely be able to meet the projected national security needs over the next decade. However, the US is rapidly approaching a decision point with respect to its aging launch infrastructure and space industrial base overcapacity. This decision could have a dramatic effect on US national and economic security in the 21st century.

The cost of maintaining the current infrastructure of launch facilities, satellite construction high bays, environmental test facilities, and four major launch vehicle manufacturing plants is likely to be prohibitive. To remain competitive, many corporations have already reduced personnel significantly, as mentioned earlier, with further streamlining possible. Many of the companies also plan to follow teaming, consolidation, and downsizing strategies to achieve the profitability required.

Although the US space industry used to boast a comparative advantage in efficiency, technology, and economies of scope and scale in space (primarily due to the large US investment in technology), the advantage is waning. Foreign national security exploitation of space is becoming increasingly widespread. It suggests opportunities to economize in sharing space investment with allies. However, in future military conflicts the U.S. could face opponents with significant military space capabilities attained through such constructive engagements.

The following sections discuss key issues for the major segments of the US space industry within their international context: launch, remote sensing, communications, navigation, weapon systems, science and manned space exploration.

### Launch Systems

The US expendable launch vehicle infrastructure is slowly recovering from a long period of neglect. This neglect, combined with a diverse stable of aging launch vehicles that are often specially configured for each payload, result in long lead times and difficulty in meeting launch schedules. These problems are magnified when US launch capabilities are compared to those of the European Space Agency (ESA). The current series of Ariane 4 launch vehicles are impressive in terms of cost and schedule reliability. The follow-on Ariane 5 promises to be even better.

#### *Current Launch Systems*

Until the mid-1980s, the United States had, in essence, a nationalized system of space transportation controlled and managed by NASA and the DOD. Expendable launch vehicles (ELVs), which were largely based on converted ICBMs (*Delta, Atlas,* and *Titan*) and NASA's manned, reusable Space Shuttle formed the basis of this system. The US government

controlled access to space for the entire free world, launching European and Asian satellites in addition to its various US customers. This situation changed with a sequence of events which began in the 1970s.

In the United States, a decision was made to phase out the US ELV program in favor of (what was expected to be) the more cost effective Space Shuttle under development at that time. This controversial decision spurred interest in several US launch vehicle manufacturers to begin offering their vehicles commercially (McDonnell Douglas - *Delta*, General Dynamics - *Atlas*, and Martin Marietta - *Titan*). President Reagan encouraged the private sector to do so in 1983, designating the Department of Transportation (DOT) as the lead executive agency to facilitate space launch commercialization. Congress then passed the Commercial Space Launch Act of 1984 to further encourage and define the government's role in this commercialization. However, the Space Shuttle, which became operational in 1982 as well, remained the centerpiece of the US space launch program. By 1984, it was clear that the Shuttle's cost effectiveness had been significantly overestimated. As launch costs grew and foreign competition increased, the US government began subsidizing Shuttle flights. In the face of the subsidized competition from the Shuttle and offshore, the emerging US commercial space launch industry withered. McDonnell Douglas and General Dynamics began closing down their vehicle production lines in 1985 while Martin Marietta focused on producing *Titans* for DOD.

In 1986, the explosion of the *Challenger* forced the US to reassess its space launch direction. The mistaken over-reliance on the Shuttle for access to space was dramatically revealed in the aftermath of the *Challenger* tragedy. A new space policy was released in August, 1986, which declared a need for assured access to space using a mixed fleet of ELVs and Space Shuttles. It also severely restricted NASA's ability to launch commercial satellites on the Shuttle to only those which required the Shuttle's "unique" abilities. The US government selected McDonnell Douglas and General Dynamics to begin producing *Delta IIs* and *Atlas IIs*, respectively, to meet the DOD launch requirements "with the specific intent that these vehicles also be made available commercially." The US space launch industry had been reborn.

Today, industry capabilities are spread across the spectrum from small to large lift capacity, as indicated in Figure 4. Increasing commercial demand for lower costs will force the U.S. to abandon its launch capability or make the investment necessary to remain competitive.

From the standpoint of dependability, our systems have approximately a 93% launch success rate. One area where our launch systems are least dependable is that in meeting launch schedule demands. Because of the long processing and integration times and the fact that each vehicle is customized for specific payload, there is little or no flexibility to recover from schedule slips. Our launch systems and payloads are not responsive. It is difficult to change launch priorities even with months of advance notice. We have little or no capability to launch on need or to surge.

Today's commercial space launch industry may be positioned to play an even more important role in the future with respect to US national security. Many defense policy makers and advisers are calling for the integration of the commercial and defense industrial bases and increased government reliance on commercial industry to meet defense needs. Defense

U.S. Space Launch Industry

| Company | Vehicle | *LEO Capacity | Cost ($M) |
|---|---|---|---|
| EER Systems | Conestoga | 418 lb | N/A |
| Orbital Systems | Pegasus | 814 | 10-12 |
| | Pegasus-XL | 960 | |
| McDonnell Douglas | Delta II 7320 | 6600 | 36-45 |
| | Delta II 7925 | 11100 | 41-50 |
| General Dynamics | Atlas I | 13000 | 65-70 |
| | Atlas IIA | 15700 | 80-90 |
| | Atlas IIAS | 18000 | 114-130 |
| Martin Marietta | Titan IV/NUS | 39000 | 186-207 |
| | w/ SRMU | 49000 | 186-207 |
| | Titan IV/Centaur | 10200 (GEO) | 262-286 |
| | w/ SRMU | 13500 (GEO) | 262-286 |

* LEO - Low Earth Orbit (approx 100 nm circular)
GEO - Geosynchronous Orbit (22000 nm)

Source: Kolcum, E.N. "NASA, Pentagon Chart Ambitious Launch Vehicle Program" Aviation Week and Space Technology, March 16, 1992.

**Figure 4**

Secretary Les Aspin referred to this as the "spin on" of technology from commercial to defense.

This merger of the commercial and defense activities has actually been developing in the space launch industry since its rebirth following the *Challenger* accident. For example, the DOD contract for the *Atlas II* incorporated many commercial practice, including the purchase of launch services instead of hardware. In fact, DoD enjoyed reduced launch costs from economies of scale when General Dynamics decided to produce more than 60 Atlas vehicles by 1997 for the commercial launch market. In addition, both the *Delta II* and *Atlas II* use government owned or controlled vehicle processing and launch facilities at Cape Canaveral Air Force Station, FL. The performance of the vehicles also ties the defense and commercial space launch communities closely together. Failures in either defense or commercial launches affect the other. Consequently, the health of the commercial space launch industry is increasingly important to the ability of the US military to maintain its assured access to space.

***Increasing International Competition***

As mentioned earlier, the global launch market suffers from overcapacity (see Figure 5). US and European commercial launch capacity alone is 25-30 medium and large satellites per year with the Japanese expected to average four per year by 1995. In addition, the Chinese launch service, China Great Wall Industry Corp (CGWIC), may have the capacity to launch four or more per year in this decade. Arianespace continues to dominate the world commercial space launch market capturing approximately 60% market share with General Dynamics second followed by McDonnell Douglas.

Foreign Space Launch Industry

| Country | Company | Vehicle | *LEO Capacity |
|---|---|---|---|
| Europe | Arianespace | Ariane 4 | 10100-15400 lb |
| | | Ariane 5 | 42000 |
| China | CGWIC | Long March 3 | 11000 |
| | | Long March 2e | 19400 |
| | | Long March 3a | 18700 |
| Russia | Glavcosmos | Proton | 44100 |
| | | Zenit | 33100 |
| Japan | Rocket Sys | H-2 | 20700 |

* LEO - Low Earth Orbit (approx 100 nm circular)

Source: Gabler, E. 'Product & Service Pricing: Launch Vehicles' SPACE ECONOMICS (Vol 144) Washington DC, 1992.

**Figure 5**

The most formidable supplier in the future, however, could be Russia with its ability to double world commercial space launch capacity. The Russians are the wild card in any future market performance calculations. While advertised as a one-time exception for the INMARSAT contract, the 1992 decision of the Bush administration to lift the previous ban on launching satellites with US components on Russian launchers may have opened the door for their entry into the market. The Russians have long been known for possessing a comparative advantage in their ability to successfully launch satellites quickly and reliably. While they may not have adequate cost accounting, their price for the INMARSAT launch was approximately 50% that of a similar *Ariane* launch. This potentially devastating Russian competition combined with the recent European dominance of the market has raised questions regarding the survivability of the US commercial launch industry into the next decade. Most analysts agree, however, that the key to US competitiveness will be the renovation of its launch infrastructure.

### *An Aging Infrastructure*

US commercial firms depend on an aging, government controlled space launch infrastructure of vehicle processing and launch facilities based on 1960's technology. The vast majority of commercial launches take place from Cape Canaveral where the facilities are antiquated when compared with the more modern facilities of Arianespace. Some Air Force estimates indicate a requirement for $1 billion in repairs and improvements over the 1990s. Some of this renovation is currently underway at Cape Canaveral Air Force Station where more than $40 million has been spent since 1991. At the heart of this issue, however, is whether or not it makes sense to "band-aid" old facilities and technology or spend the money to develop a modern approach to space launch. A recent Aerospace Industries Association (AIA) report found that while the current infrastructure was antiquated, overly labor intensive, lacking commercial perspective, and dominated by government priorities, the market demand did not warrant the construction of modern commercial spaceports. However, interviews with several of the commercial satellite producers and users of space indicate that launch costs and ease of access are the major factors driving the future development of their industry. Providing a low cost, easy access to space, therefore, may dramatically increase demand. In fact, US satellite manufacturers are urging more open access to the low cost Russian and Chinese launchers for that very reason. This presents a dilemma for the government in attempting to pursue the best course of action for both the commercial space launch and satellite industries. Indeed, resolution of many of the issues facing the US commercial space launch industry today centers dramatically on the role of the US government.

### *Future Systems*

Current US launch vehicles are able to keep up with the reduced space payload demands resulting from overall federal budget reductions. Therefore, they support the foreseeable needs for payload weight to orbit. However, the current systems fail miserably in meeting the affordability, reliability, and operability criteria needed for a robust US launch capability to compete in the global market. This could seriously impact US national security in the future.

The longer term issue for space launch is how to invest increasingly scarce research and development dollars. The alternatives cover a technical range from evolutionary to revolutionary. All are expensive. Without a specific requirement to satisfy, new and different launch capabilities are likely to sustain only minimal funding for a low level research effort. Difficult decisions remain for the administration to make on alternatives. Among the options:

- National Aerospace Plane (NASP) derivatives
- Delta Clipper
- Spacelifter

With limited dollars and skeptical support from Congress, the administration will have to limit options, and concentrate efforts on one (maybe two) specific programs.

<u>NASP</u> Although the NASP is clearly a hypersonic technology program and not a launch vehicle, its proponents hold to their vision of a derivative capable of operational space

launch. This represents a high risk, long term approach to leapfrog existing expendable launch technologies.

Delta Clipper A rocket-powered, VTOL, single stage to orbit vehicle, the Delta Clipper is a 1960's idea updated with new structural and rocket engine technologies. Originally funded as an SDIO project, a one third demonstration model is currently undergoing VTOL tests as a prelude to possible full scale development. However, the Delta Clipper's challenge is its single stage to orbit capability due to the extreme sensitivity to weight and engine performance.

Spacelifter The Spacelifter program proposes to develop a medium lift, expendable launch vehicle in the 20,000 lb payload to LEO range, designed from the ground up to be affordable and provide for timely launches. It seeks to reduce costs through common facilities, components, and manufacturing and operations infrastructure, along with highly flexible production rates.

**Satellite Systems**

The US satellite manufacturing infrastructure is healthy in terms of capital, plant, and technology. Nevertheless, it also has a substantial overcapacity resulting from decreased government spending. Ongoing corporate initiatives to downsize should compensate for reduced revenues, keeping the industry relatively healthy.

***Remote Sensing***

Remotely sensed satellite imagery has supported civil and military needs in time of peace and conflict. Desert Shield/ Desert Storm demonstrated the importance of satellite imaging systems to our US military forces, and the rest of the world. Although remote sensing covers a wide array of systems, this report will focus on Landsat satellites, the primary US entry in the global commercial remote sensing market, and its foreign competitors. In addition, polar orbiting weather satellites will be discussed.

Civil use of commercial remotely sensed imagery has been broad-based, supporting environmental control and monitoring; agriculture, soil, forestry, mineral, and energy resource management; and land use and urban planning. Military and intelligence use of commercial imagery has been limited, primarily because of imagery resolution.

Landsat History. US remote sensing efforts began at NASA in September 1969. On 23 July 1972, the Earth Resources Technology Satellite (ERTS-1) was launched. In 1975, the ERTS system was renamed Landsat and declared operational.

In 1979, Presidential Directive 54 turned over Landsat operations to the Commerce Department's National Oceanic and Atmospheric Administration (NOAA). The Land Remote Sensing Commercialization Act of 1984 (P.L. 98-365) led to NOAA contracting with the Earth Observation Satellite Corporation (EOSAT) for the operation of Landsats 4 and 5. EOSAT was also given sole marketing rights for unenhanced Landsat imagery, which was available to all users on a nondiscriminatory basis.

From 1986 through 1991, Landsat commercialization efforts were complicated by the *Challenger* accident and inconsistent congressional support and funding. Landsat commercialization had failed and the future of Landsat was in doubt. On 5 February 1992, President Bush signed National Space Policy Directive 5, which directed NASA and DoD to jointly develop a follow-on Landsat 7 system. On 28 October 1992, the Land Remote Sensing Policy Act of 1992 (H.R. 6133) was enacted, further defining national remote sensing policy.

Landsats 4 and 5 are still operating today, with Landsat 6 scheduled for launch in July 1993. In October 1992, General Electric Astro Space was awarded a contract to develop Landsat 7, with launch planned for late 1997.

Landsat Description. Landsats 4 and 5 carry two sensors, a multispectral scanner (MSS) and a thematic mapper (TM). The MSS provides 80 meter resolution imagery in four spectral bands (visible green and red and two reflected infrared bands). Additionally, the TM provides 30 meter imagery in six spectral bands and a 120 meter thermal infrared band. Landsat 6, while similar to Landsats 4 and 5, will also include a 15 meter panchromatic band in its TM sensor.

Landsat 7. DoD and NASA are currently developing Landsat 7, which will have the same sensors as Landsat 6. Landsat 7 will also have the capability to geoposition (or control) its imagery to the earth's surface. In support of DoD, Landsat 7 will add a second higher-quality sensor, the High Resolution Multispectral Stereo Imager (HRMSI).

HRMSI will add an enhanced four band multispectral sensor with 10 meter resolution and a 5 meter single-pass stereo panchromatic sensor. Distribution of imagery will take approximately one week during routine operations, but as little as two hours after imaging during crisis operations. The enhanced capabilities of Landsat 7, particularly HRMSI, will lead to increased use by DoD, supporting a wide range of military and intelligence applications.

Foreign Competition. Over the past several years, increased numbers of non-U.S. earth imaging satellites have been launched. Landsat's primary competitor on the commercial market is France's System Probatoire d'Observation de la Terre (SPOT) satellite. Launched in 1986, SPOT has two sensors, a 20 meter three-band multispectral imager and a 10 meter panchromatic imager. Panchromatic imagery from multiple imaging passes can be used to provide a stereo capability.

There are currently two SPOT satellites (SPOT 1 and 2) in operation. SPOT 3 is scheduled for launch in 1993 and SPOT 4 is to be launched in 1997 or 98. Both SPOT 3 and 4 will have the same imaging capabilities as the current systems. Plans call for developing SPOT 5 with improved spatial resolution (five meters for panchromatic and 10 meters for multispectral). Additionally, a single pass stereo imaging capability is to be added for the panchromatic mode. SPOT 5 launch is planned for early next century. Additionally, France has teamed with Spain and Italy to develop a military reconnaissance satellite called HELIOS.

Russia launched ALMAZ-1 in 1991. ALMAZ-1 has a 15-30 meter radar imaging capability. Additionally, the Russian military, through Soyuzkarta, has begun selling higher resolution military reconnaissance imagery, a film-based (vice digital) product with advertised

resolutions of less than 5 meters.

In 1991, the European Space Agency (ESA) launched the Earth Resources Satellite (ERS-1) which provides 30 meter radar imagery and lesser quality infrared imagery for ocean study. More advanced ERS-1 sensors are planned for the late 90s.

Japan's Environmental Resource Satellite (JERS-1) offers radar and multispectral imagery at a resolution of 18 meters. As a follow-on, the Advanced Earth Observation Satellite (ADEOS) is under development. Japan has plans to launch 14 ADEOS satellites by 2005, with visible and near-infrared sensors providing imagery with resolutions as high as 8 meters.

China has launched more than a dozen remote sensing and reconnaissance satellites, two (FSW-1 and 2) in the last half of 1992. The FSW series satellites are aimed at supporting microgravity science, earth resources, and military reconnaissance. China, along with Brazil, is also developing two remote sensing satellites named CBERS. CBERS is scheduled for launch in 1993 with an electro-optical sensor providing imagery at a resolution of 40 meters.

India launched the Indian Remote Sensing (IRS-1A) satellite in 1988 providing imagery at 36.5 meters. The second generation IRS-1E is scheduled to be launched in 1993, providing 20 meter multispectral and 10 meter panchromatic imagery. Reportedly Israel, Pakistan, Argentina, South Africa and Taiwan are also pursuing remote sensing capabilities. Table 2 provides a listing of the current and proposed remote sensing satellites.

## Operational & Proposed Earth Remote Sensing Satellites

| Satellite | Owner | Repeat Coverage | Launch Date |
|---|---|---|---|
| LANDSAT-5 | U.S. | 18 days | 1985 |
| LANDSAT-6 | U.S. | 18 days | 1993 |
| SPOT-3,-4 | France | 26 days | 1994<br>1998 |
| MOS-1,-1B | Japan | 17 days | 1987<br>1990 |
| JERS-1 | Japan | 41 days | 1992 |
| ALMAZ-1 | Russia | 1-3 days | 1991 |
| ERS-1,2 | ESA | 3 days | 1991<br>1994 |
| RADARSAT | Canada | 16 days | 1995 |

Source: Guide to Space Issues, CNSS Report, Dec 1992.

**Table 2**

Polar-Orbiting Satellites Since geostationary satellites are located over the equator, their images are not useful above 55 degrees north latitude and below 55 degrees south latitude. This is due to the curvature of the earth and the oblique viewing angles. To provide satellite coverage for these northern and southern latitudes, polar-orbiting satellites are used. Polar-orbiting meteorological satellites are low earth orbiting (LEO) satellites and they encircle the earth about every 100 minutes. One satellite provides coverage of any earth location about twice a day. To satisfy military and civil requirements, two polar-orbiting programs have evolved.

Defense Meteorological Satellite Program -- The military polar-orbiting program is called the Defense Meteorological Satellite Program (DMSP). The program calls for two LEO satellites. The orbiting times of the satellites are determined to satisfy military and national program needs. DMSP satellites have infrared and visual sensors to provide day-and-night coverage. In addition, the satellites have sensors to measure surface wind speeds and vertical profiles of temperature and moisture. These sensors are optimized for cloud and microwave imagery. Also, the DMSP satellites have an encryption capability to prevent others from receiving and using the data.

Currently, the program is in good shape. There are two fully operational satellites on orbit. According to the DMSP program element monitor, there are enough satellites in various stages of construction to last until the year 2005. In addition, the satellites have been performing very well and lasting longer than their mean expected life.

Polar-Orbiting Operational Environmental Satellites -- The civil polar-orbiting satellites are called Polar-Orbiting Operational Environmental Satellites (POES). These satellites are acquired by NASA and operated by NOAA. Like the DMSP, the civil program calls for two LEO satellites and they have visual and infrared sensors to provide day-and-night coverage. This program is in good shape, having enough satellites currently on order to cover their mission through the year 2000. According to a recent NASA briefing, launches are scheduled for June 1993 and May 1994 to keep this program fully operational.

Unlike DMSP, the POES sensors are optimized for acquisition of atmospheric vertical profiles to support computer modeling. The orbit times of these satellites are determined to support the computer modeling schedule. Since POES and DMSP satellites are optimized for different purposes, they do not have the same sensors. In addition, the NOAA satellites do not have an encryption capability. However, DOD units acquire POES data to supplement the DMSP data.

### *Telecommunications*

The world outlook for telecommunications satellites has never been more promising or more competitive. Beyond the top three US manufacturers of large commercial spacecraft -- GM Hughes, Martin Marietta (formerly GE Astro-Space), and Loral Corp., each vying for a piece of the action -- growing pressure on the marketplace comes from satellite builders in France, Italy, Germany and the United Kingdom.

Other potential competitors also lurk in the wings, with the massive, if less exotic, capabilities of the former Soviet Union representing a possible future presence. There are also emerging Asian technology centers, with China, Japan, and Korea all dedicated to some degree of self-sufficiency in satellite manufacturing. Whether these evolving capabilities will be introduced into the marketplace with any effect is a matter of debate, but the European manufacturers will likely be the prime competitors for the foreseeable future.

There is a trend towards standardization in the design of satellites among U.S. and foreign satellite manufacturers. Although the design of each satellite is unique because of its mission, the incorporation of a standard "bus" design within a series pays manufacturing benefits. The satellite "bus" refers to the sustaining portion of the spacecraft to which different sensors or electronics can be mated. Several satellite manufacturers have developed a standard bus which they can easily modify for different functions. The trade-off in the weight of a standard bus versus the reduced manufacturing costs must be made by the customer.

<u>Commercial Communications Satellites</u> The Communications Satellite Act of 1962 created a private company (COMSAT) to provide satellite telecommunications for the U.S. This government-sponsored monopoly would be half public and half private and closely regulated. COMSAT was started in February 1963 to create a global satellite communications system. COMSAT is the designated U.S. signatory to international satellite communications agreements.

The International Telecommunications Satellite Organization (INTELSAT) is an international consortium created in 1964 to provide fixed, land-based satellite communications. Initially consisting of twelve countries, INTELSAT membership is now 119. INTELSAT

operates a non-profit cooperative for member nations. Ownership shares are computed each year based upon use. Non-member nations can lease capacity from the system. INTELSAT collects working and investment capital from members and earns revenues from the sale or lease of satellite capacity. Member countries average a 14% return on investment. Technical improvements to the system decreased service charges by 95%.

Similarly, the International Maritime Satellite Organization (INMARSAT) was established in 1979 to provide global mobile satellite communications for commercial and safety applications at sea, in the air, or on land. Headquartered in London, INMARSAT has 67 member countries. The INMARSAT satellite network provides direct-dial telephone, telex, facsimile, electronic mail, and data applications for maritime use; flight-deck voice and data, automatic position and status reporting, and direct-dial telephone for aircraft; and two-way data communications, position reporting, electronic mail, and fleet management for land mobile communications.

INMARSAT initially leased satellites, but has recently completed their own constellation. INMARSAT has also improved its terminals by using digital technology and is currently marketing INMARSAT-M, low-cost briefcase terminals for worldwide coverage. Their Project 21 initiative promises go-anywhere, pocket-sized telephone service by the end of the decade.

Other international communication satellite organizations have also been established. European Telecommunications Satellite (EUTELSAT) service, serving Europe, operates four satellites, all launched by Ariane and providing mostly TV service. ARABSAT consists of two operating satellites, ground control and support facilities. PANAMSAT, provides special services to Europe and Latin America. Orion has placed an order for a turnkey system providing mostly VSAT (Very Small Aperture Terminals) network services.

On the U.S. domestic scene, there are 25 satellites owned or operated by seven US companies, which provide multiple services including Direct Broadcast Service (DBS), paging, TV, communications, and VSAT for corporate communication networks used for real-time feedback and ordering by corporations such as Wal Mart. Other countries with communications satellites include Indonesia, Mexico, Canada, Australia, India and formerly Soviet services now serving the Confederation of Independent States, Europe and former satellite countries. Figure 6 shows the world's distribution of satellite communications capacity (excluding Russia and China, which do not yet participate in the commercial market).

International Satellite Communications Suppliers The technology essential to satellite communication is furnished primarily by Hughes (the dominant and most competitive commercial communications satellite producer in the world), Martin Marietta (formerly GE Astrospace), Loral (formerly Ford Aerospace), and ESA member companies such as Domier, MBB (Deutches Aerospace) and Aerospatiale. The distribution and development of communications satellite equipment suppliers mirror the trends in satellite communications capacity depicted in Figure 6. American companies pioneered communications satellites and are still able to dominate price competitions based on their efficiency and economies of scale and scope. Three fourths of the world's commercial communication satellites are the product of three American companies (one of which, Ford Aerospace, was recently purchased by a

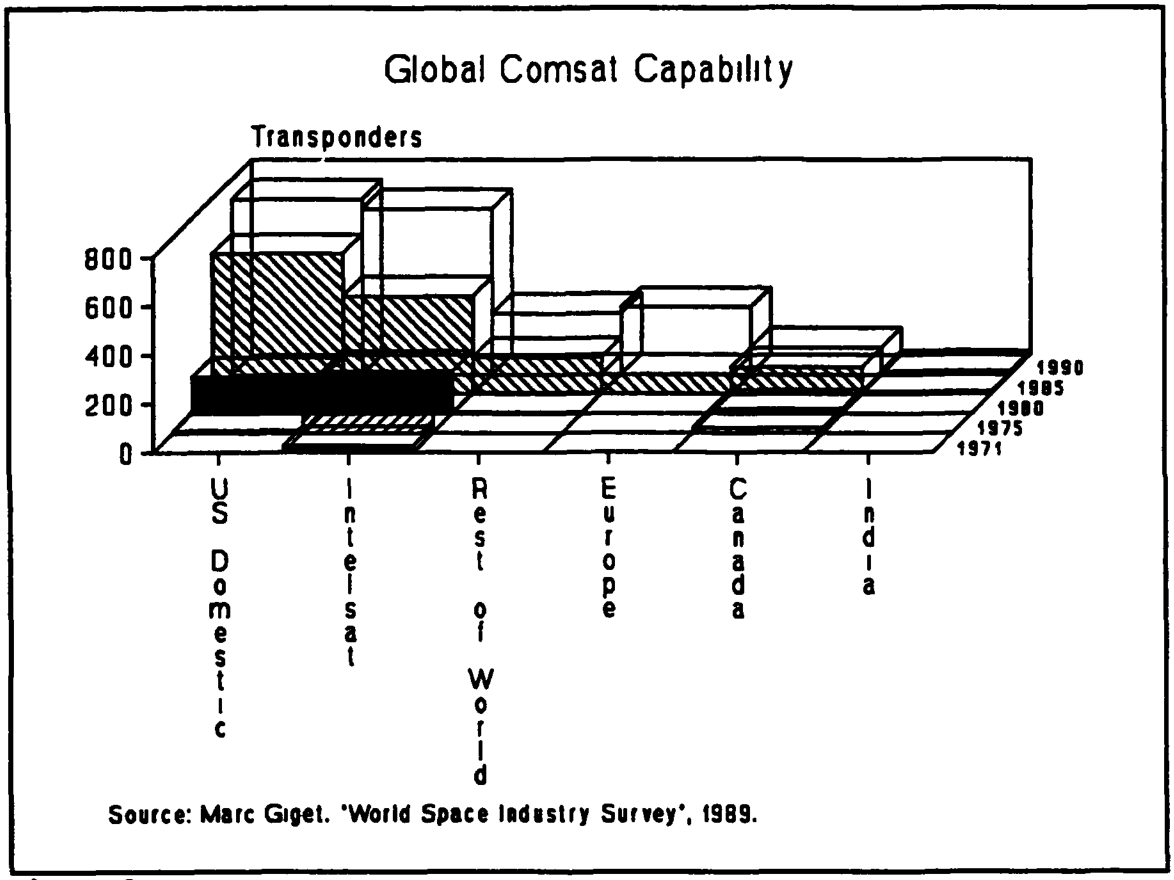


**Figure 6**

European consortium.) But, American industry now shares the marketplace with European, Japanese, and Canadian companies. Britain, France, Germany, Japan, Italy, and Canada all have one or more companies each that have demonstrated the ability to act as a prime contractor in integrating subsystems and components into successful communication satellites of roughly equivalent technology and capability.

| International Suppliers for IntelSat VI<br>Source: Hughes Corp, 1992. | | |
|---|---|---|
| Country | Company | Item |
| Canada | COMDEV | Mux/Filter |
| Canada | Spar | Receiver |
| Canada | Spar | Driver Amp |
| Canada | Spar | Elec Pwr Conditioner |
| France | Alcatel | Receiver |
| France | Alcatel | Output Mux |
| France | Thompson | TWT Amplifier |
| Italy | Selenia | Transponders |
| Italy | Selenia | Antennas |
| Japan | NEC | Upconverter |
| Japan | NEC | Receiver |
| Japan | NEC | Power Amplifier |
| Japan | NEC | Master Oscillator |
| Japan | NEC | Distribution Unit |
| UK | BAe | Reflector |

Figure 6

As a result most communication satellites built today involve international collaboration. Some of those relationships began as deliberate technology transfers through offsets required as a condition of contract award. Over time they have evolved into supplier relationships beneficial to both sides. Some of the suppliers (Japanese semiconductor electronics for example) offer unique comparative advantage. In competition for domestic US satellites, US prime contractors now routinely use international suppliers of components and major subsystems. Table 3 lists a fairly typical distribution of suppliers for the communication payload of an Intelsat VI satellite. This trend applies even to foreign military systems.

***Navigation Systems***

In 1973, the Global Positioning System (GPS) Program was initiated when the Air Force, Army, Navy, Marine Corps, and Defense Mapping Agency combined their technical resources to develop a highly accurate space-based global navigation system. GPS is a constellation of 21 satellites (plus 3 spares) in six orbital planes. Using a GPS set, with signals received from the satellite constellation, military users can achieve accuracies of 16 meters (spherical error probable) in 3-D and 8 meters (circular error probable) in 2-D mode. Civilian users can obtain accuracies of 40 meters (circular error probable) in 2-D mode.

It was the experience gained in Desert Shield/Desert Storm that brought to light the importance of GPS. Navigation in the featureless Iraqi desert would have been virtually impossible without GPS. GPS use has exploded over the last two years, with many new applications emerging. It is expected that the improved capabilities of GPS will, in time, replace previously developed navigation systems, (e.g., Transit, Omega, Loran, etc.). Table 4

provides a more detailed comparison of navigation system performance.

Navigation System Comparison
Source: GPS NAVSTAR Users Overview, Sep 86.

| System | Position Accuracy (m) | Velocity Accuracy (m/sec) | Range of Operation | Comments |
|---|---|---|---|---|
| GPS | 16 (SEP) 3-D | › 0.1 RMS/Axis | Worldwide | 24 hr All-weather Increased accuracy for authorized users |
| Loran-C | 180 (CEP) | N/A | U.S. CONUS & Coast Selective O'seas | Localized coverage Limited by skywave interference |
| Omega | 2200 (CEP) | N/A | Worldwide | 24 hr All-weather VLF propagation anomolies |
| Std INS | 1500 (CEP) | 0.8 | Worldwide | 24 hr All-weather |

Table 4

Aircraft and Weapons. GPS receivers are being integrated with the inertial navigation systems (INS) of aircraft, cruise missiles, and other autonomous standoff weapons. Through signals received from GPS satellites, heading and velocity errors are reduced to support enroute navigation, handoff to more accurate terminal sensors, and/or direct attack of a target. GPS-aided INS guidance has two primary error sources which affect overall system accuracy: the uncertainty of the weapon's position in flight, and the error in target location.

Differential GPS is being investigated as a means to reduce the uncertainty of the weapon's location, providing improved delivery accuracy to support attacking harder targets. In Differential GPS, a base receiver is placed at a known (surveyed) location which serves to transmit relative correction to the GPS receiver on the aircraft or weapon. Using differential GPS, weapon location can be determined to approximately 1 meter versus 16 meters using a single receiver on the weapon.

Logistcs Fleet Monitoring. Using GPS, in conjunction with two-way mobile messaging systems, fleets of trucks, trailers, trains, railcars, and shipping containers can be tracked, with

locations displayed in real time on a digital map backdrop.

Moving Map Displays. Traditionally, moving map displays have been employed on aircraft (e.g., F/A-18, AV-8B, etc.). The aircraft's position (via INS) is displayed on a digital map on a cockpit display to orient the aircrew with the ground below.

However, moving map displays are not limited to aircraft. The Navy is installing GPS receivers on its ships, which, with digital nautical charts, will support navigation and display the ship's position. Likewise, the Army is moving towards installing GPS in land combat vehicles. Used with Tactical Terrain Data or other large scale digital map backdrops, GPS will support navigation and command and control on the battlefield.

Additionally, in 1990, the Japanese electronics firm Pioneer (along with Trimble Navigation, a US GPS receiver manufacturer) began marketing a dashboard navigator for automobiles in Japan. The system displays the vehicle's position on a digital dashboard display.

Surveying. GPS has revolutionized surveying. Using Differential GPS, surveys can be performed at a quality equal to the best existing primary survey methods. The benefit of GPS for surveying is not limited to its precision, but also its efficiency. GPS surveyors are not limited to short baselines and line-of-sight between survey points. By eliminating these problems, GPS surveyors no longer have to build survey towers to see over trees or traverse around rough terrain. As a result, GPS surveys provide substantial savings in time and effort over traditional methods.

Civil Aviation The Radio Technical Committee on Aviation (RTCA), Special Committee 159 completed work in April 1991 on supplemental standards for GPS and began work on minimum operational standards for use as the sole means of navigation. In September 1991, the International Civil Aeronautics Organization's (ICAO) Tenth Air Navigation Conference endorsed a new architecture for air navigation and control called Future Air Navigation System (FANS). The FANS incorporates GPS and GLONASS (Russia's analog of GPS) and is expected to become the sole means of navigation for civil aviation, replacing current terrestrial navigation (but not approach and landing) aids. Navigation accuracy is expected to be good enough for non-precision approaches. Differential GPS methods are also being studied for use as a precision approach aid.

**Weapon Systems**

President Ronald Reagan's Strategic Defense Initiative (SDI) has been "downsized" and reoriented to only field the Global Protection Against Limited Strikes (GPALS) system.

GPALS is a defensive antimissile system designed to protect the United States, its forces deployed overseas, and its allies against limited or accidental ballistic missile attacks. GPALS consists of two key elements: theater defense against theater and tactical ballistic missiles and national defense against strategic ballistic missiles attacks on the continental US.

The only space-based components remaining within the SDI/GPALS program are surveillance assets. Brilliant Eyes (BE) was designed to be a constellation of satellites which

would circle the globe and watch for ballistic missile launches. It would enable elements of GPALS to look over the horizon and overcome some of the limitations of the system's ground-based radars. With the current Congressional and Executive branch plan to economize on all space surveillance assets, Brilliant Eyes will probably be combined with the Air Force's Follow-on Early Warning System (FEWS) now under development.

FEWS will replace the current Defense Satellite Program (DSP) constellation which is aging and degrading. FEWS will provide superior capabilities to detect theater and short range ballistic missile launches necessary for effective GPALS targeting and interception.

While support for space systems which enhance the tactical warfighters' capability (communications, navigation, surveillance, and weather) has increased, other military/weapon system uses of space have all but disappeared. This trend will likely continue for the foreseeable future.

**Science and Manned Space Exploration**

Since the Russians launched their 184 pound Sputnik satellite in 1957, US national space policy has been politically framed in terms of achieving and maintaining world preeminence in space science and exploration. Unlike the days of *Apollo,* however, when NASA enjoyed almost carte blanche spending privileges, today's more fiscally constrained environment places greater emphasis on projected costs and associated benefits. While it is clear that continued US leadership in space will enhance national security and strengthen the technology base, it is equally clear that a more deliberate national space policy, one that is more cost effective and integrated among defense, civil, and commercial sectors is needed.

Space science can be broadly categorized as either basic or applied. Past accomplishments like the discovery of the Van Allen belts, the development of X-ray astronomy, and quantum leaps in monitoring global weather patterns, all have their origin in basic science endeavors. These achievements were, in turn, supported through advancements in applied science are as such as propulsion, aerodynamics, automation, and robotics. A continued strong US presence in space exploration will require firm national commitment in both basic and applied space science fields.

US exploration initiatives can be categorized under two mission areas: Mission to Planet Earth (MTPE) and Mission from Planet Earth (MFPE). MTPE entails the use of satellites, probes, and other instruments to increase man's understanding of the earth and its environment. The Earth Observing System (EOS) is an example of a major MTPE project. EOS encompasses the launch of a series of spacecraft that will monitor the earth's land, atmosphere, oceans, and selected life forms over a fifteen year period beginning later this decade.

The US has maintained an aggressive and generally successful manned space program since the creation of NASA in 1958. After the exciting *Apollo* program that culminated in the spectacular lunar landings, space scientists realized that the US needed more cost effective access to space for manned presence. This effort culminated in the Space Shuttle program which had its first flight in 1981. As mentioned earlier, the predicted cost savings for Shuttle were never realized, however. Currently, Shuttle related operations

consume nearly 40% of NASA's annual budget.

In January 1984, President Reagan committed the nation to the goal of developing a permanently manned space station within a decade. The US joined Canada, Japan, and 9 of 13 ESA nations to plan an ambitious laboratory in space. Originally, the space station *Freedom* was to be a research lab, manufacturing facility, observatory, transportation node, spacecraft servicing station, assembly plant, storage depot, and strategic staging base for further lunar and planetary exploration.

The *Challenger* accident, downturns in the US and world economies, and escalating development costs have forced several redesigns of space station *Freedom*. President Clinton recently directed yet another program restructure to a design which has been scaled back to include life sciences and microgravity laboratories only.

The costs of using the Shuttle to build and operate a space station have renewed the debate over manned vs unmanned space activities. Many scientists claim that the potential scientific benefits of current plans are not worth the costs. President Clinton's current direction is to come up with a program that can be executed with about half the current funds. This has forced a review of the entire NASA organization to find ways to streamline costs. There are five NASA centers involved in the space station effort. Many observers have claimed that conflicts between these centers and their large bureaucracies were major contributors to the complexity and escalating costs of the space station.

While a manned space exploration program has many advantages, including providing a focus for education and international cooperation, the costs involved have caused the US to reexamine its priorities and rethink current efforts. For the US to retain its manned space capabilities, it must find a more cost effective and efficient way to access and operate in space. This may include cost sharing with other space faring nations.

**International Space Programs**

***Europe***

The European Space Agency was formed on July 31, 1973. It was a consortium of originally 10 European nations (now 13) and, under the leadership of French, initiated funding for the development of the *Ariane* launch vehicle. On May 26, 1980, a consortium of 36 European aerospace companies, banks and the French space agency CNES (Centre National d'Etudes Spatiale) created the Arianespace company to take over Ariane program management, production, launch, and marketing after a series of eight promotional launches. After the first commercial launch Arianespace assumed full operational control. ESA continues to fund new launcher development and testing, additional launch site construction, and user support.

*Ariane* progressed through various stages of development and the current operational vehicle is *Ariane 4* with *Ariane 5* under development. The *Ariane 4* is a flexible expendable launch vehicle that can be configured in a variety of ways to tailor the vehicle to match specific payload and mission requirements. Specifically, the core rocket is comprised of three stages and can be fitted with from zero to four solid or liquid booster rockets to augment

payload performance. Liftoff weight of the vehicle can be varied and can be as high as 470,000 kg. Payload capability is 1900-4,200 kg (GTO). A modification to the third stage is expected to increase the payload capacity of the basic Ariane 4 configuration (44L) to 4,400 kg ( GTO). A variety of satellite payloads are possible for a given launch including two primary payloads with up to six auxiliary payloads up to 50 kg each.

The *Ariane* vehicles are launched from the Guiana Space Center (CSG) at Kourou, French Guiana. The proximity of it to the equator (5.23 degrees North latitude) provides a 17% payload advantage over Cape Canaveral for eastward launches. It also has the advantages of low population density and mild weather patterns throughout the year. Another advantage is its wide available launch azimuth of 104 degrees from 349.5 to 93.5 degrees.

The launch cycle covering all *Ariane 4* operations at the CSG is normally two months per vehicle. Tasks include vertical assembly and checkout of the three vehicle stages, payload and nose fairing installation, equipment checkout and the launch countdown. Up to 10 launches are possible per year.

Separate preparation and launch zones are connected by a double railroad track. Operationally, one rocket is stacked in the vertical assembly building of the preparation zone while another rocket is undergoing final launch checkout and payload installation by the mobile gantry on the pad.

The *Ariane* launch vehicle flexibility results in lower costs to customers while being responsive to their particular payload and mission needs and schedule requirements. Overall reliability for *Ariane 4* is 91.7%. Arianespace is able to attract a majority of the commercial market as a result of their responsiveness.

To continue their dominance of the market, ESA is now developing the *Ariane 5* with a planned first launch in late 1995. Arianespace plans to overlap *Ariane 4* and *5* operations during a period of about three years in order to mitigate the risks of transitioning to the new booster. The European Ministers approved the *Ariane 5* development program on November 10, 1987--seven months prior to the first launch of *Ariane 4*. Development costs for *Ariane 5* are estimated at $4 billion. More recent estimates place this figure close to $6 billion. In 1992, the largest contributors to ESA's Ariane 5 program were France 45%, Germany 22%, and Italy 15%.

Unlike U.S. ELV's which have evolved from a variety of Intercontinental Ballistic Missile (ICBM) designs and technologies, the *Ariane 5* launch system (booster and launch base infrastructure) began with a clean sheet of paper approach. This new launch system is being optimized for the commercial space launch market.

The *Ariane 5* vehicle will continue the piggyback payload approach (i.e., launching more than one spacecraft at a time on the same booster) successfully demonstrated by Ariane 4. This method allows two or three customers to share the Ariane launch costs. The *Ariane 5* cargo envelope is approximately the same size as the Space Shuttle cargo bay. This will allow the *Ariane 5* to capture Shuttle class payloads should the need arise.

*Ariane 5* will not only serve the international commercial launch market, but also the

needs of the scientific community, European military reconnaissance programs (France's HELIOS spacecraft) and Europe's manned spaceplane--the Hermes. However, increasing costs and decreasing requirements for a manned spaceflight capability have essentially canceled the Hermes program.

The man-rating requirement to launch Hermes will tend to increase costs in the design, production, and operation of *Ariane 5*. Reliability requirements (.99 for the *Ariane 5* lower composite section) are more stringent for manned flights, and any increase in cost may be passed on to commercial users. However, customers may be willing to accept this increase in cost in return for potentially lower launch insurance premiums and more responsiveness.

An *Ariane 5* goal is to achieve a 10% reduction in recurring launch costs over the *Ariane 4*. Increased lift performance for the *Ariane 5* (6800 kg for a single launch and 5900 kg for a dual launch to geostationary transfer orbit injection) over the *Ariane 4* (4460 kg and 4060 kg for single and dual respectively) will result in an approximate 40% decrease in cost per kilogram to orbit over the *Ariane 4*.

The nations of Europe recognized that the enormous expense of a viable space program required collective and cooperative action on their part in order to achieve adequate progress in an autonomous world class space program. Their individual economies and other competing requirements for their resources led them to work collectively to achieve what they could not individually.

The development of the *Ariane* launch system was a voluntary program among ESA members. Nevertheless, each nation considered its commitment to be long term and similar to a treaty commitment. Nations agreed to commit to the program and its cost estimate, unless there was a variance of 20% in additional cost. This voluntary, collective commitment coupled with a clear objective provided a managerial and policy foundation that lead to a dedication of purpose. However, with the cancellation of the *Hermes* manned space program, some members are questioning the need for this heavy lift vehicle.

The Europeans have made a strong commitment to the modernization of their space program. The development of the *Ariane 5* launch vehicle and the infrastructure improvements at the Kourou launch site are designed to reduce launch costs and provide a capability to support a potential manned space program. ESA has placed emphasis on cooperation among its member nations rather than competition--they're competing together for a large share of the launch market, not for who among them will build the next launch vehicle. The business approach adopted by the Europeans is a blend of managed competition and cooperation with the expectation that each participant will receive a fair return on their investment. The business cornerstones include customer support, production quality, and launch vehicle reliability.

***Russia***

With the end of the Cold War and the collapse of the Soviet Union the dynamics of the world's space launch market fundamentally changed. Currently, ambitious international alliances and cooperation between Russia and European nations highlight strategic changes

that are beginning to affect the space industry. The Cold War thaw and the resulting excess ballistic missiles from SALT and START agreements may work to flood the world launch market with stockpiled Russian launch systems no longer needed for nuclear delivery vehicles. This, combined with similar excesses from the U.S. nuclear missile drawdown threatens the worldwide space launch industry.

The decline of the Soviet Empire has had other indirect effects on the space industry. The post Cold War budgets for space programs are also in decline in Europe and the U.S. in response to those nations' view of a strategically less threatening world. This decreased emphasis on the need for defensive satellites systems in space has helped further erode the demand for satellites and launch vehicles.

The US response to the current situation can significantly impact the future global economic and military freedom of action available to the US and its allies. Initial indications are that European nations have recognized the need to include Russian space industry capabilities in their strategic planning while the US has been slow to determine an appropriate strategic course of action. The choice now is to watch events unfold in the space industry between the Russians and European nations or actively pursue opportunities which the current Russian situation presents. What is at stake is the leadership of space activities for the next decade and beyond, accompanied by all the benefits that leadership role will bring. Alternatively, the US could continue to proceed with a relatively independent space program and risk watching the other leading space nations unify their efforts and resources to take the lead in space.

The Russian space program has several positive aspects that could be used to further the exploration of space by the US or other nations. A few negative aspects of their space industry must also be dealt with if the US decides to use some of their capabilities.

Positive Factors

Launch Facilities - Tyuratam and Plesetsk have a proven track records as operational launch complexes with the capability for large volume operations. Plesetsk, the most northern complex in the world has the advantage of being able to place payloads into polar orbit with much less thrust required than from other complexes. Plesetsk has also launched over 1250 vehicles into orbit and, like Tyuratam has a total integration capability. This has helped produce very impressive launch pad operations when compared to other vehicles:

On pad operation time:
- Delta -- 39 days
- Atlas -- 59 days
- Titan -- 97 days
- Space Shuttle -- 37 days
- Ariane -- 20 days
- All Russian systems except Energiya -- 2 days

Launch Vehicles - The launch complexes have superb flexibility and have launched a variety of vehicles over the past three decades including the SS-4 Sandal, SS-5 Skean, SS-6 Sapwood, SS-9 Scoup, Proton and the Energiya. Currently the launch vehicles with the most

utility for Europe and the U.S. are the Proton and Energiya. The versatile Proton can be launched with two, three or four stages, has over a 96% reliability rate and is the premier space launch competitor in the world-wide launch market. The Proton's capabilities threaten to disrupt the launch vehicle industry in Europe and the United States. The Energiya is a heavy-lift launcher capable of placing over 18 tons into geo-synchronous orbit and was built for launching the Buran, the Russian space shuttle. Potentially, the Energiya could be used for launching large cargos such as Space Station Freedom.

Space Engineering Infrastructure - An impressive aspect of the Russian space industry capability are the extremely talented scientists and engineers that supported their past programs. The former Soviet states graduated over 450,000 scientists and engineers each year compared to 200,000 in the U.S. Many of the best and brightest of these ended up in the space industry - the premier Soviet industry that sought to provide credibility for the USSR with other world nations. Much of this capability remains but stands to be dispersed if these individuals cannot find profitable work in space activities. Many European nations are seeking means to use this capability. For example, Aerospatiale has over 15 contracts with Russia, some of which use Russian scientists and engineers to validate concepts for systems in design.

Learning Curve and Production Rate Savings - The Russian launch systems have launched over 2350 vehicles compared to 1030 for the US. In addition, during the 1980s they averaged over 90 launches per year compared to 16 per year for the US. The cost improvement and production rate savings from the Soviet system offer significant savings compared to those in the US.

Other Favorable Factors - The low cost of labor in Russia and the simplicity, flexibility and standardization between launch vehicles and launch support infrastructure make it much more operationally oriented than those used in the US.

Negative Factors

Low Technology - Many of the Russian launch systems achieved success through use of "brute force" and not through technological achievements that US systems and Ariane have used to provide for accurate placements of satellites in space after a smooth delivery.

Environment - The Russian launch systems and complexes do not have the environmental monitoring systems and pollution prevention measures that are required of US systems.

Cost Accounting Data - The Communist totalitarian economic system did not require the development and use of a cost accounting system. Therefore, the US does not have an adequate method of determining what the Russian launch systems and services really cost. This places the Russians and those who do business with them at a distinct disadvantage in reaching good business decisions.

Business Acumen - The lack of a free enterprise culture and the development of leaders to run businesses in Russia put them at a disadvantage in an internationally competitive situation. This factor could also harm their ability to attract customers.

### *China*

China's space program can be traced back to 1958 when a ballistic rocket test center was established in Inner Mongolia. China launched its first satellite in 1970 on a launch vehicle developed in parallel with its CSS-3 missile program. Space launch capability continued to be directly derived from the Chinese missile systems. The Chinese have developed four classes of space launch vehicles of the "Chang Zheng" (or Long March) family.

The Chinese space program plays a significant role in implementation of the nation's technological strategy which focuses on space and other advanced aerospace programs. China's current five-year plan identifies telecommunications as one of the nation's highest priority programs. Other missions include maintaining independent access to space to protect national security interests, supporting advanced research and development, and providing commercial launch services to generate hard currency to fund the program and support the country's economic growth. Discussions with one Chinese official who had been on cooperative assignment at Dornier for several months, indicated that the Chinese wanted to offer their cheap land, labor, and capital to gain technology transfer in cooperative space ventures.

China's space program is small in relative size to the US and former Soviet Union. They have a less extensive range of launch vehicles, a limited range of application satellites (communications, meteorological, etc.) and some recoverable satellites. Yet despite being crippled by the withdrawal of the Soviets early in their program and the void of the Cultural Revolution, they have managed to advance their program. By one Chinese account, China's space technology investment is less than one percent that of the U.S. and former USSR. Western estimates place the cost of their program at $1.5 billion annually.

According to the China Great Wall Industry Corporation, the commercial marketing arm for the Chinese space program, China's space industry employs 200,000 people, of which one third are engineers and technicians. Many are educated in the U.S. and then return to their country where they provide a highly skilled, low cost labor pool.

China entered the commercial launch industry in 1986 after the *Challenger* accident and other expendable launch vehicle failures. The Reagan administration approved the licensing in 1988 of three US-made satellites to launch on Chinese Long March vehicles to permit the US satellite industry to remain competitive while promoting mutually beneficial US-Sino trade relations. However, the launch pricing practices by this non-market economy has been a continuing source of concern for U.S. launch vehicle manufacturers.

China has suffered two recent failures in their commercial launch program which may reduce their desirability as a launch vehicle provider in the future. Also, their technology lags the industry leaders by 5-15 years.

In addition to commercial launches, China has entered into partnership with Brazil in two joint ventures for communications and earth sensing satellites. China announced in 1988 that it planned to develop a manned space program to include a small shuttle and space station. The Chinese have also expressed interest in participating in a project to launch a human crew to Mars.

*Japan*

Japan is the principal supplier of semiconductor electronics for many space applications (US companies are still the source of choice for radiation hardened electronics). After a first generation of satellites and launch vehicles purchased or licensed from US companies, Japan has invested heavily in developing indigenous capabilities. Its success has been mixed.

In launch especially, its ambition for the leading edge in technological performance has caused it difficulty. For example, its cryogenic engine development followed the NASA Space Shuttle engine lead in employing the staged combustion cycle. In contrast, the Ariane engines employ the gas generator cycle which provides a lower level of performance, but with greatly reduced complexity, cost, and development risk. As a result of the choice of cycle and propellant, repeated testing failures and fires have plagued Japan's engine development.

The persistence and comprehensive scope of Japan's space program indicates a commitment for the long term. As a small indication of their long-term perspective, Japan built extensive, modern launch pad infrastructure at a location limited (by pre-existing fishing rights) to launch operations during only a few weeks of the year. Development into an operational launch complex will require long term political commitment to restructuring land use and displacing a politically powerful industry. Japan is investing in ground stations that may provide profitable commercial services in the future. In addition, they commercially provide a large percentage of ground station equipment, microwave dishes, and space-based telecommunications support equipment to worldwide users.

## OBSERVATION/CONCLUSIONS

### US Space Policy Implementation

Access to space and the application of space for military, scientific, and commercial purposes is vital to our national and economic security. This importance of space and its pervasiveness in the military, scientific, and commerce sectors of the federal government requires the coordinated implementation of an integrated space policy. As detailed in this report, the international competitors of the US have become adept at the execution of such a policy to generate comparative advantage in the space global market.

*The policy outlined in 1989 by the US, and detailed in the beginning of this report, has not been properly integrated and executed.* It is evident from discussions with both US domestic space organizations and international space activities abroad that the US space program and industry suffer as a result.

A policy organization is necessary to establish program direction in terms of scope, priority and pace across the federal government for military, scientific and commercial applications. It should also establish policy in terms of international collaboration and cooperation in science, US economic competitiveness in the international space commercial market, and military cooperation with friends and allies.

**Launch Systems**

*Assured access to space is the key critical element of US national space capability and security.* Since the early 1960s, the US has relied primarily on modified ICBMs to launch satellites. These launch vehicles evolved over the years, but are still based on 1950's and 60s' vintage technologies. Based on older technologies for guidance and propulsion system and using inefficient, manpower intensive launch infrastructure, these vehicles limit our space launch capabilities to "launch when available" status instead of "launch on demand" in a cost effective manner.

As demonstrated in Desert Storm and projected for future potential regional conflicts, space assets are critical for battlefield success. In addition, US military force reductions around the globe will increase the demand for space systems to provide surveillance, navigation and targeting, and communications. *Therefore, the changing global threat will increase the need for responsive, affordable launch systems to meet national security requirements.*

Significant foreign investment in new space launch systems such as the European's *Ariane* has negated the US lead in launching commercial satellites. *In addition, the Russian and Chinese launchers pose significant threats to both US domestic and allied launch industries. This situation could threaten US economic security in the long term.*

Although these worldwide competitive pressures and security considerations exist, *declining budgets limit the US government's ability to fund the broad based restructure of the US launch industrial base needed to significantly improve US launch capability.*

*In the nearer term, a slightly different problem exists for the US commercial space launch industry - too much government involvement.* While the US government has acted to develop an infant commercial space launch industry through encouraging legislation and civil/defense contracts, it has also maintained a much more hands on approach with respect to facility control, vehicle processing and launch, etc. *Many argue that as a consequence, the industry remains too oriented toward the "political/military" versus the "consumer" to be competitive in the next century.* This hands on government approach may make it difficult for the industry to achieve the 25-50% reduction in costs and prices estimated to be necessary by the year 2000 to remain competitive in the international market.

*The role which the US government plays in the launch arena is critical.* It must successfully negotiate several paths. First, it must play the *honest broker with respect to other nations to ensure fair trade and accounting practices* are followed to prevent foreign monopolization of the commercial launch industry. However, protectionist policies to preserve the US launch industry may negatively impact the satellite producers who are increasingly required to provide a satellite and launch service package at a competitive price. Second, it

must *share the responsibility for funding the development of a cost effective launch infrastructure with industry or international partners*, if possible, to provide the critically needed affordable, responsive, and reliable access to space. Finally, it must *withdraw from its past dominant role in commercial space launch to allow the free market forces to shape a more efficient industry.*

**Remote Sensing**

The enhanced capabilities of Landsat 7, particularly HRMSI, will support a wide range of military and intelligence applications, including mapping, targeting, mission planning, command and control, terrain analysis, general search and change detection, etc. *In light of Landsat 7's increased importance to military applications, a release policy must be developed which considers the economic, social, and political factors.* Currently, the only restriction recommended is to delay imagery distribution during time of crises, thereby limiting its use as a near-real time intelligence source. Further restrictions would severely limit the benefits to the civil user community.

Polar Orbiting Weather Satellites *Government officials have proposed combining the military and civilian polar-orbiting weather satellite programs to reduce cost. It is estimated that with convergence the government can realize savings on the order of $40-$80 million per year.* A significant savings can occur just by consolidating the ground control segment. In the past, national security issues and the conflicting requirements caused the defeat of this proposal. With the current efforts to reduce the federal deficit and declining DoD and NOAA budgets, it is time to reconsider this proposal. In addition, the current satellite buys for both programs will end soon after the year 2000 and both organizations are starting now to develop their next block of satellites. This presents an opportunity for DoD and NOAA to work together and develop a satellite to satisfy both organizations' requirements.

*DoD and NOAA must resolve four issues to converge these programs.* First, the DoD will insist on an encryption capability to ensure data deniability. A compromise may be possible since the satellites can be programmed to transmit in the clear for portions of the orbit and during peacetime. This leads to the second issue of control of the satellites. The DoD will want to control the satellites to ensure data availability and deniability in the event of crisis or conflict. The third issue is that convergence will require some modification and possible compromise on the sensors for the satellites. But, it may be possible to develop sensors to satisfy most if not all of the requirements. Finally, DoD and NOAA will have to come to an agreement on the orbital times for the satellites. This may be possible by developing a three satellite program and still realize a significant savings. DoD and NOAA should start meeting now to resolve these issues and jointly develop their next block of satellites.

**Telecommunications**

Previously the military led industry in research and development and spin-off technology to commercial industry. Now the tables have turned and *there are many opportunities for the military to spin-on commercial technology trends in satellite communications.*

Very Small Aperture Antenna Terminal (VSAT) satellite communications are used to

provide dedicated, medium-capacity, point-to-point communications. Formerly inaccessible locations can be quickly connected provided frequencies and real estate are available. Presently this technology is in limited use; however, as quick reaction and worldwide commitments increase, so should the use of VSAT.

Other implications from trends in commercial satellite technology could prove useful to the military as they evolve. The exploding trend for the use of cellular telephone technology led to Motorola's *Iridium* concept for worldwide cellular telephone coverage. As the military threat changes to a more uncertain geographic area, American forces will be sent to areas where the existing communications infrastructure is unlikely to serve their needs (e.g., Somalia). When the *Iridium* technology is developed and fielded, forces would only need to carry cellular phones to stay in touch.

*Space-based information systems from the entertainment industry could provide dual-use capabilities for the military.* Direct Broadcast Satellite (DBS) allows the reception of video through an 18-inch dish antenna, which will greatly increase portability. Video on demand for households could become battlefield imagery for battalions. Digital Audio Broadcast (DAB) technology provides audio radio broadcast from satellites with potential worldwide coverage. DBS technology could augment national security requirements for emergency broadcast services as well as provide entertainment for our dispersed forces. Since our military forces travel frequently by air, inflight telecommunications via satellite could be useful. Such a system will provide connectivity from the aircraft into the public switched telecommunications network, allowing calls from airborne passengers to anywhere a telephone can reach.

A word of caution is in order on the use of commercial systems. Since the above technologies are targeted for commercial use, the design included no provisions for security. If any of these systems are to be considered for classified military use, some type of cryptographic security is required.

**Navigation**

GPS supports numerous military applications and provides a tremendous market opportunity for civil applications. Additionally, the U.S. government is missing out on tremendous revenues by providing GPS signals as a free service to worldwide users. *Methods to capture GPS-user fees should be explored.*

During Desert Shield, U.S. Forces procured and used large numbers of commercial GPS receivers. Because of this, the Selective Availability (SA) option on GPS was turned off, allowing civil users to receive improved positional accuracies, normally reserved for military users. Since that time, SA has been reinstated, causing an outcry among civil users. The debate rages on whether to continue to output degraded accuracies to civil users, or provide one (best) accuracy to all users. However, SA should be maintained because civil users can derive precise accuracies using differential GPS methods.

**Manned Space Activities**

Current US manned spaceflight is centered on the Space Shuttle. Shuttle operations consume nearly $6 billion a year or nearly 40% of NASA's budget. With yearly costs for

building the planned space station at between $2-3 billion, the entire space station effort over 30 years is estimated to cost the US nearly $200 billion. There are an estimated 75,000 jobs currently tied to the space station effort.

*At the present time, there is little need for manned space activity for military or commercial purposes.* Many science, research, and exploration missions can be done with unmanned spacecraft. However, manned space efforts enjoy the support of most Americans as well as many of the space faring nations as the focus of the pioneering spirit and the need for man to continue to expand his sphere of influence. *The time has come to make manned space efforts affordable through international cooperation.*

**International Cooperation**

The federal deficit and huge expense of space activities will require the US to make choices in how it conducts its space program. It is necessary for the US to consider international cooperation and collaboration in space exploration and manned space flight to ensure that adequate progress is achieved. *Collaboration will also help to make available scarce funds for US space activities that are not conducive to collaboration.* Activities not conducive to collaboration relate to national security and critical defense technology transfer concerns. In these areas, the US may have to go it alone.

*Limited cooperation may be desirable in military application to achieve interoperability among satellites between the US. and its friends and allies.* Interoperability will ensure contingent capability in the event of a regional crisis or conflict and it will also facilitate the coordination of coalition efforts.

*With respect to the Russians, the US should work with them in joint ventures and determine how to use their capabilities without undermining US industry.* This may include US/European/Russian long-range alliances for the exploration and use of space while maintaining US strategic space capabilities to ensure national security and economic opportunities for the US space industry.

## RECOMMENDATIONS

Based on the observations and conclusions detailed in this report, the following actions are recommended:

1. **Resurrect the former National Space Council to properly implement an integrated space strategy**. The Council should be assigned responsibility to:

- create a strategic space vision
- develop an integrated policy for military, scientific, and commercial applications of space
- build an overall space program plan
- formulate a supporting budget
- present and defend the space program to Congress
- oversee the performance of the space program

2. **Form a government/industry consortium within the US or with international partners to share the risks and program funding for a next generation space transportation system such as "Spacelifter".** Developing and operating such a system would best support defense, civil, and commercial requirements by providing a reliable, responsive and affordable means of accessing space. This consortium could be modeled after several successful existing organizations such as INMARSAT or ESA which are based on the concept of risk sharing economic interdependency coexisting with industrial competition.

3. **Negotiate fair trade "rules of the road" within the international space launch market**, especially the non-market economic nations such as Russia and China.

4. **Maximize DOD efforts toward joint commercial versus military only endeavors, integrate military with civil and commercial activities at every opportunity.** Promote commercial space activities by commercializing parts of the military and civil sectors and creating investment incentives for developing space commerce. This would also apply to the military space launch area where government oversight could be significantly reduced or eliminated.

5. **Do not directly subsidize launcher and spacecraft makers, but allow the market activity to shrink the space industry based on economic demand.** Let industry downsize and team with foreign competitors.

6. **Develop a release policy for Landsat 7 imagery which considers economic, social, and political factors due to its increased importance in military applications.**

7. **Form a DOD and DOC (NOAA) working group to plan and oversee convergence of the DOD and DOC polar orbiting weather satellite programs.**

8. **Reorient civil space activities towards research and development and infrastructure development, and get away from operational activities.** Reduce NASA center activity and spin off as much as possible to commercial enterprises. Every effort should be made to conduct most civil space activities with international partners.

9. **Encourage international cooperation for future scientific research programs on a cost shared basis.** Consider using foreign capabilities when there is a clear cost advantage and reciprocal foreign commercial opportunities.

10. **Reduce the space station *Freedom* program to a more economical and incremental cooperative project that can utilize other launch systems besides the space shuttle.**

11. **Concentrate long range research and development in a single stage to orbit capability rather than on a large space station.** Reduce Space Shuttle funding and reinvest in new manned space launch systems.

## SUMMARY

The US Space Industry will most likely be able to meet the projected national security needs over the next decade. However, the US space program suffers from a failure to implement an integrated space policy which sets proper priorities.

Many of the organizations visited indicated a need for the US government to negotiate with the other space faring nations, especially the non-market economies, for fair trade "rules of the road." At the same time, the government should withdraw from its overactive role in domestic commercial space areas.

Most importantly, the US is at a crossroads in space launch. It must either develop a viable launch infrastructure for the 21st century in an international context or accept the loss of world leadership in this vital security area.

Further reduction of excess capacity in industry and more international cooperation in the future are warranted. Many innovative approaches to international cooperation exist and should be looked at in all arenas of the space industry, especially manned space efforts.

With these and the other actions outlined in this report, the US Space Industry can remain a viable national resource into the next century.

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# INDUSTRY STUDIES

# #10

# TELECOMMUNICATIONS/
# INFORMATION SYSTEMS

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## PLACES VISITED

### Domestic

| | |
|---|---|
| TRW | Vienna, Va. |
| Electronic Data Systems | McClean, Va. |
| Northern Telecom | Raleigh Durham, N.C. |
| Digital Equipment Corp. | Maynard, Ma. |
| BBN | Cambridge, Ma. |
| MIT Media Labs | Cambridge, Ma. |
| Thinking Machines | Cambridge, Ma. |
| MITRE Development Center | Burlington, Ma. |
| CNN | Atlanta, Ga. |
| General Telephone Electric | Needham, Ma. |
| IBM | Manassas, Va |
| Motorola | Phoenix, Az. |
| Xerox Palo Alto Research Center | Palo Alto, Ca. |
| Space Systems/Loral | Mountain View, Ca. |
| Rational | Santa Clara, Ca. |
| Sun Micro Systems | Palo Alto, Ca. |
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### International

| | |
|---|---|
| U. S. Embassy, Japan | Tokyo, Japan |
| Ministry of Post & Telecom | Tokyo, Japan |
| NHK Broadcasting | Tokyo, Japan |
| Mitsubishi Electric Co. | Tokyo, Japan |
| IBM Japan | Tokyo, Japan |
| Sony Inc. | Tokyo, Japan |
| NEC | Tokyo, Japan |
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## INTRODUCTION

The Telecommunications and Information Systems industry is extremely diverse. It covers business areas such as printing and publishing, computer manufacturing, data processing, voice and data communications, and entertainment. An industry-wide movement toward digital technology is the thread that binds together each of these segments. Today, the entire contents of the Library of Congress can be stored digitally and can be electronically transferred to any location on earth in minutes. As technology develops, elements of the information industry continue to converge, blurring the lines separating each business area and rapidly swallowing new business areas.

From a Defense point of view, information technology has proven to be a force multiplier and provides commanders the potential for a complete electronic view and control of the battlefield. Advanced information systems will soon allow "virtual reality" combat training, effectively simulating actual battle scenarios.

The accelerating application of information technology in the private sector and decreasing federal expenditures have moved the Department of Defense into the role of a minor player in the development of new information technologies. Commercial off-the-shelf (COTS) hardware and software are increasingly evident in U.S. Government purchases.

This paper will report on the structure, performance, and outlook of the American segment of the telecommunications and information industry. At the end of the document, a suggested course of government action designed to assist the industry will be presented.

## INDUSTRY STRUCTURE

### Computer Equipment and Software

The computer manufacturing and software development industry covers the entire business spectrum from oligopoly for super computers and mainframes to pure competition for personal computers (PC's) and related software.

***The Federal Share*** Computer equipment manufacturing represents a $54 billion industry. Government purchases amount to less than 10% of the total. The Government's market share has declined over the past decade along with its ability to influence the industry. Currently, civilian industry drives the state-of-the- art technology. Grants from the Federal Government tend to support basic research in such areas as high performance computing and demonstrations of new communications initiatives.

***Jobs*** Computer equipment manufacturers have experienced their fourth straight year of declining employment. These reductions are the result of productivity improvements as well as corporate restructuring to counter the lower profit margins in an increasingly competitive market. Most hardware manufacturers expect additional workforce reductions of 10% to 30% in the coming two years.

Software developers are in a better position. As the world leaders in software

development, American software companies are still enjoying modest employment growth.

***Environment*** In addition to the rapid technological changes confronting the industry, there are many legislative hurdles which need to be overcome. The manufacturing segment of the industry is pressured by an increasing number of environmental issues which range from water and air pollution to the disposal of solid waste products. Circuit board and floppy disk producers have been particularly affected by environmental legislation. However, most seem to have met those challenges and substantially cleaned up their processes.

***Property Rights*** Intellectual property rights remains a key item of interest to software development companies. In 1992, the Ninth Circuit Court of Appeals ruled that reverse engineering of software was legal and did not violate U.S. copyright laws. The court explained that reverse engineering was appropriate in order to ensure compatibility and interoperability among the various operating systems and applications. However, piracy of U.S. software remains common practice in a number of countries. In 1992, the U.S. Congress attempted to reduce the frequency and intensity of software piracy by setting higher uniform penalties for copyright infringement. Greater government participation in the copyright process is necessary to adequately protect U.S. intellectual property rights.

**Information Services**

The Information Services industry is composed of approximately 26,000 diverse businesses and employs over one million people. It consists of electronic information services, data processing and network services, and computer peripheral services. The industry operates in a purely competitive environment. It is relatively easy for small, entrepreneurial firms with high-quality products to establish themselves in one of the many "niche markets." A key characteristic of the Information Services industry is the ability to rapidly generate profit since there is a reduced requirement for capital investment compared to the manufacturing sector of the industry. Three main sectors of this industry include:

***Electronic Information Services*** that provide access to either on-line, CD-ROM, or audiotext database services. The United States is world-class in its ability to store and retrieve data. Over one third of the revenue for this industry segment is derived from foreign sources.

***Data Processing and Network Services*** are increasing as more and more firms "outsource" data processing needs as an element of a corporate restructuring plan. Although there are over four thousand firms in the business, the industry tends to be top-end concentrated. One half of the revenue for this component is earned by the ten largest firms.

***Computer Professional Services*** covers a number of areas including advice on design, selection, and installation of computer systems as well as operations and maintenance training. Of the four thousand U.S. firms which provide some form of computer professional services, eighteen hundred of them offer systems integration services. The entire services market is expected to grow. The continued evolution of open systems architecture provides users with an ever increasing choice of computer equipment and software. No longer tied to a single vendor, customers now require professional help to integrate their diverse systems.

Competition among service providers is expected to grow as the market becomes increasingly crowded with down-sized and restructured firms. Customer-poor defense and aerospace companies, which have considerable excess capacity and are looking for markets in which to expand, have diverted much of their efforts into this field in search of increased opportunity.

***Comment*** Historically, federal, state, and local governments have been important customers in the information services market. However, with continuing government expenditure reductions, the industry is redirecting its marketing efforts towards commercial accounts. Nonetheless, the federal government remains the single largest customer and supports industry growth through high performance computing, communications research, and President Clinton's desire to establish an American "information highway."

The federal government impacted the industry in the 1992 legal ruling that Regional Bell Operating Companies (RBOCs), could enter the information services market. This ruling has spurred the RBOCs to form partnerships with existing information service firms in order to explore promising new opportunities such as "video dial tone" which would allow us to interact with our televisions in much the same way we now use our telephones.

Other issues facing information services providers include privacy protection, fraud, and illegal access such as use of "900 services" by underage minors.

**Telecommunication Services**

More than two thousand companies employing 860,000 people provide telephone service to over 88 million households and 30 million businesses nationwide. Telephone service is characterized as either local, long distance, or mobile wireless.

***Local Telephone Service*** The forced break-up of American Telephone and Telegraph (AT&T) in 1984 resulted in a common carrier network of 161 local access transport areas (LATAs). Telephone service within the LATAs is the responsibility of the local exchange carriers (LECs). Although there are over thirteen hundred local telephone companies, the majority of telephone service is provided by the seven Regional Bell Operating Companies and General Telephone and Electric (GTE).

The local telephone services market is capital and manpower intensive. The LECs operate as regulated utilities whose rate structures are determined by local utility commissions. A benefit of the public utilities rate structure is that special services such as 911 emergency service and telephone service for the deaf are subsidized with little apparent cost to individual subscribers.

***Long Distance Service*** Long distance telephone service is provided by over four hundred commercial carriers which are dominated largely by three companies. Many smaller long distance service companies provide point-to-point business connections. Because of the 1984 divestiture dictum, AT&T is the only long distance carrier whose business activities are restricted and whose rates are federally controlled.

***Mobile Wireless Communications*** The U.S. cellular industry continues to enjoy annual

growth in excess of 20%. In 1992, each of the original 734 market locations was being served by at least one of the two cellular operators licensed in each market. Nationwide, the total number of subscribers exceeds 10 million. Two major cellular telephone service providers are actively engaged in establishing a seamless, nationwide network. Ongoing commercial projects would expand personal wireless communications to a grand global scheme by using 60 to 80 low orbit packet-switching communication satellites.

Increasing public demand and the subsequent rapid expansion of the mobile communications industry have led to a call for increased frequency spectrum allocation for the civil sector. This has led the Federal Communications Commission (FCC) to review and to perhaps reduce the military frequency allocation.

***Comment*** The telephone services industry faces federal, state, and local regulatory constraints such as frequency restrictions, regulated prices, and manufacturing prohibitions. To offset these restraints, the telephone industry hopes to capitalize on President Clinton's proposal for an information highway system. In an extraordinary show of solidarity, all of the major telecommunications service providers have signed a policy statement supporting the administation's high performance computing and communications vision.

In a further move to ease regulatory restrictions, they have offered to commit up to $125 billion over the next seven years to create the infrastructure necessary to support the "information highway" network. The money would be made available only if they receive approval to offer restriction-free services. Cable television, newspaper, and various other publishing media companies are expected to oppose these proposals because of a perceived threat to their market share.

**Telecommunications Equipment**

Employment in the U.S. telecommunications equipment industry continues to decline. Companies are laying off workers in an effort to control costs. The industry faces severe competition from overseas markets, especially those on the Pacific Rim. Currently, Japan, Hong Kong, South Korea, Singapore, and Taiwan provide 52% of America's equipment imports. Japan provides 33% of the total. The current trade imbalance is occurring primarily because of American offshore purchases of customer premise equipment. American industry still enjoys a trade surplus in high-tech network and transmission equipment.

The past year's growth rate of 23% reflects a dramatic increase in the American manufacture of cellular telephone equipment. High demand has led to the establishment of a fully digital cellular telephone network, and two U.S. firms have already applied for patents in order to manufacture the hardware.

***Comment*** U.S. telecommunications manufacturers face a multitude of trade barriers and standardization problems which restrict the industry's ability to sell equipment overseas. However, through tough political negotiations, limited inroads are being made, particularly in Asian markets.

American legislative restrictions also affect the domestic telecommunications equipment industry. Along with the divestiture of AT&T in 1984, the newly created Regional

Bell Operating Companies were prohibited from manufacturing equipment for their own use. This reorganization freed the RBOCs from bondage to AT&T's monolithic equipment supplier--Western Electric, but forced them to acquire their equipment on the open market. Currently, several legislative initiatives are pending which would permit the RBOCs to reenter the equipment manufacturing field.

## INDUSTRY PERFORMANCE

The U.S. telecommunications industry has maintained its presence across the business spectrum and even increased its influence in some areas. Nonetheless, a large portion of the industry has undergone structural changes which were driven by global economic pressures and rapidly changing technologies. These pressures and changes must be appreciated in order to fully understand the significance of the performance metrics. A brief description of the changes in question follows:

***Worldwide Economic Downturn*** While the U.S. economy has experienced 19 months of halting recovery from its most recent recession, the rest of the world remains in a recessionary cycle. The level of American exports will continue to decline as foreign countries have less money to spend for telecommunications goods and services, thereby reducing demand. In order to adjust to diminished demand, American industry has lowered prices in an attempt to maintain market share thus further reducing profits.

***Hardware Commoditization*** Rapid technical advances and aggressive competition have reduced the costs of hardware across the board and are leading to the "commoditization" of computer components and associated telecommunications devices. As a result, high-tech, complex devices are evolving to a state in which they are composed of a series of common component parts (semi-conductor chips, DRAM chips, integrated circuits, mother boards, etc.). Such components are standardized, mass produced, and have led to reduced profit margins. As a result, company unique designs and proprietary systems are beginning to give way to open systems.

***Changing Economics*** Productivity has increased in the commodity related sectors of the industry. It is influenced by the application of capital intensive automated manufacturing practices which stimulate greater output per unit of labor input. While revenues continue to grow in all areas of the industry, employment continues to decline and profit margins are shrinking.

***Shift to Software Engineering & Systems Integration*** Many firms within the industry recognize the current shift toward the commoditization of hardware and have developed strategies to compete in this new environment. High profit margins are still available in the computer software and information services segments of the industry. Traditional equipment manufacturers are now beginning to outsource hardware production in order to concentrate on software and systems integration.

The industry has shifted from one in which a few (4 or 5) leaders control most of the market (vertically integrated products and services) to one in which many firms compete horizontally in one or two business areas and achieve profitability by operating in a chosen

niche. New firms are beginning to crowd these horizontal niches (e.g. network services. operating systems, specialized software, long haul and data communications, etc.). Some defense companies with extensive systems engineering experience are also beginning to move into these niche markets as they adjust to decreased Defense budgets.

**Metrics of Industry Performance**

| Revenues (Billions $)* | | | | |
|---|---|---|---|---|
| Year | 90 | 91 | 92 | 93** |
| Information Services | 40.2 | 45.8 | 51.8 | 59.2 |
| Telcomm Services | 153.8 | 163.2 | 172.9 | 183.4 |
| Computer Hardware & Software | 59.0 | 58.0 | 60.1 | 65.0 |
| Telcomm Equipment | 17.9 | 17.0 | 16.7 | 17.0 |

* unadjusted for inflation, ** estimated

Revenues in information services have increased about 13% per year. Revenues in telecommunications services have increased about 6% per year. Revenues increased by 4% in 1992 for computer equipment and software after two flat years. Revenues for telecommunications equipment decreased slightly.

| Employment (1,000) | | | | |
|---|---|---|---|---|
| Year | 90 | 91 | 92 | 93* |
| Information Services | < 1,000.0 | < 1,000.0 | 1,000.0 | N/A |
| Telcomm Services | 925.5 | 914.8 | 881.4 | 868.0 |
| Computer Hardware & Software | 248.0 | 236.0 | 224.0 | 220.0 |
| Telcomm Equipment | 92.7 | 88.5 | 84.3 | N/A |

* Estimated

Productivity is increasing in this industry based on the fact that revenue is increasing while employment is decreasing. The number of employees increased to one million in information services in 1992, and decreased in all other segments of the industry.

| Equipment Imports/Exports (Billions $)* | | | | |
|---|---|---|---|---|
| Year | 90 | 91 | 92 | 93** |
| Computer H/W & S/W - Imports | 23.3 | 26.4 | 30.7 | 34.4 |
| - Exports | 24.1 | 25.2 | 25.5 | 27.4 |
| Telcomm equipment - Imports | 4.2 | 4.7 | 5.4 | 5.8 |
| - Exports | 2.5 | 2.6 | 3.3 | 3.8 |

* unadjusted for inflation, ** estimated

U.S. manufactured computer and telecommunications equipment remains competitive on the world market as evidenced by a net increase in exports. Unfortunately, the U.S. has a trade deficit in both areas and imports continue to increase faster than exports. American telecommunications service providers are the most competitive in the world. For information services, the U.S. has always enjoyed a positive trade balance and is expected to continue with absolute increases in the size of the surplus.

| Profitability/Profit Margins (%) | | | | |
|---|---|---|---|---|
| Year | 88 | 89 | 90 | 91 |
| Information Services | 20.39 | 15.18 | 17.87 | 19.09 |
| Telcomm Services - Local | 8.39 | 7.91 | 8.69 | 7.11 |
| - Long Dist | 25.12 | 17.20 | 20.62 | 16.42 |
| Computer Hardware & Software | 19.33 | 17.56 | 17.97 | 12.38 |
| Telcomm Equipment | 13.56 | 14.37 | 14.83 | 14.70 |

Profit margins have been relatively stable in the Information Services, Telcomm

Services, Telcomm Equipment, and Computer Software sectors of the industry. Profit margins are declining in the Computer Hardware sector.

***Conclusions*** The U.S. telecommunications industry has reacted well to the market forces, economics, and technological changes which are restructuring the industry. It continues to be the world leader in the high technology products. But Japan and the European Community (EC) are not far behind and have taken actions which seem to target American-dominated portions of the industry. These penetration strategies include the following:

1. Buying into U.S. firms to obtain desired technologies. (British firms have been investing in U.S. computer aided design and computer aided manufacturing (CAD/CAM) firms.)

2. Becoming the only supplier of component parts to U.S. firms. (Japanese firms supply virtually all flat panel displays and a very large proportion of memory chips to the U.S. dominated storage device business.)

3. Investing in university and other U.S. laboratory basic research, to gain control of patents and licenses of new technologies.

One final point on world trade needs to be made. Many American firms report considerable difficulty in entering the markets of other countries (particularly Japan and Germany). Countries often give preference to domestic suppliers and, when international competition is allowed, frequently deviate from internationally accepted standards on goods produced for domestic use. This protectionist practice encourages non-domestic products to fail local technical standards tests. This is a trade issue that must addressed in an international forum.

## INDUSTRY TRENDS AND OUTLOOK

### Industry-Wide Trends

As shown in Figure 1, there are many trends which span current industry borders. In many ways, these trends are reflections of national and global economic currents but they are also uniquely applicable to the highly technical industries highlighted by this study.

***Workforce Size*** The general trend within the major companies is "rightsizing." A decrease in total workforce has come principally from the manufacturing segments of the industry. Whether or not the service sectors will make up for manufacturing losses is still a matter of conjecture.

***Telephone Connections*** The number of U.S. telephone connections is leveling off. Population growth and workforce demographics for the next twenty years will be represented by a relatively flat curve. The slight projected increase stems mainly from cellular connections. Impressive growth for the last two years reflects a continued rise in cellular connections. However, access rights and cost of service may hold this growth in check.

***Network Connections*** This is the most dynamic segment of the telecommunications industry. There has already been tremendous growth in this service sector. Exponential growth is anticipated when the high-speed public and/or private data communications transmission networks become available.

***Processing and Storage Capabilities*** Computing power, performance, and memory/disk capacities are increasing exponentially. Manufacturers continue to find new ways to more rapidly produce items which are cheaper and smaller. Record high backlogs for the latest production items were enjoyed in 1992.

***Hardware Costs*** Automated production lines and high-volume products from foreign and domestic suppliers continue to drive down hardware costs and reduce profit margins.

***Software Costs*** The U.S. software industry was one of the fastest growing sectors of the U.S. economy in 1992. New products, particularly in the operating systems area, created new opportunities for software developers. Application tools, integration solutions, and systems software comprise the packaged software market. Integration services which make it all work together are the key to future growth.

***Bandwidth Usage*** Remarkable improvements are occurring in satellite, microwave, and cable (fiber, coaxial, and twisted pair) communication systems. Enhanced compression techniques with improved quality are being developed at an ever-increasing pace.

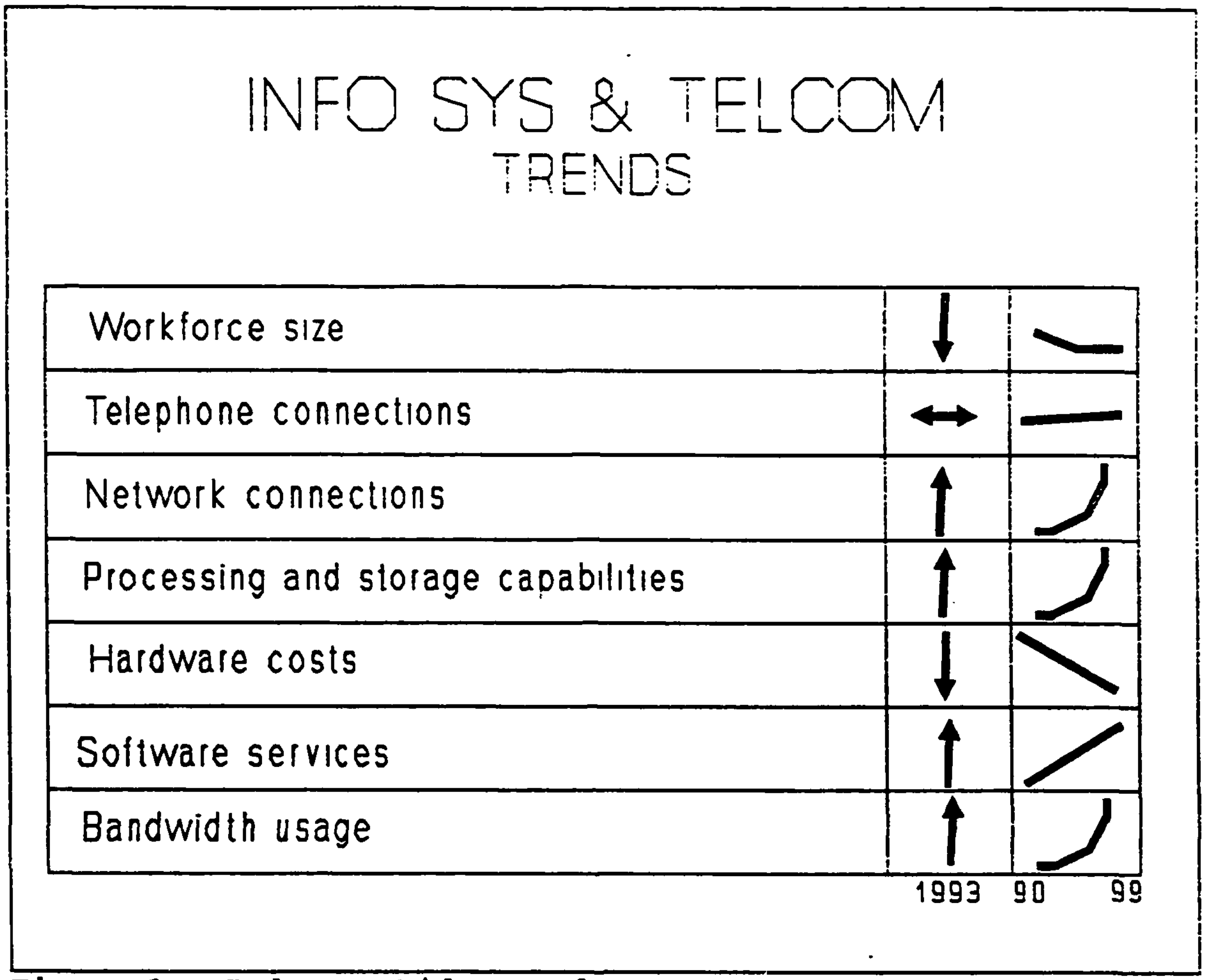


**Figure 1.** Industry-Wide Trends

**Outlook**

The outlook for the telecommunications and information systems industry for the next five to fifteen years can only be described as explosive. Vice President Gore described it as "by all odds the most important and lucrative marketplace of the 21st century." The Department of Defense is no longer the engine driving the industry's technological change. The civilian market, by virtue of its increased economic weight, is now the leading force.

The pace of technological change in the commercial marketplace is incredibly swift. Processor speed, memory capacity, and network availability are increasing almost exponentially. Although today's industry is fragmented into separate hardware, telecommunications (both manufacturing and services), information systems, and software companies, the next ten years will be a time of convergence--both convergence of media and convergence of manufacturing and systems integration.

***Convergence of Media*** "Multimedia," the current industry buzzword, is used to describe the integration of video, graphics and text. A projected futuristic notebook computer best

exemplifies such integration. The notebook is voice controlled, able to video conference easily, and allows the user to verbally access high definition data bases. In the not so distant future, video, voice, text, and graphics will travel the communications networks to be seamlessly accessed and displayed by any user. In a similar manner, computer, telephone, broadcast and cable TV, information systems, consumer electronics, and publishing will be driven to consolidate into an seamless information industry.

***Convergence of Manufacturing and Systems Integration*** Virtually all of the American manufacturing companies visited advocated a move out of the computer hardware manufacturing business and into "systems engineering." One industry official described it as "moving up the value-added chain." Reduced profit margins through the commoditization of hardware and software are driving the industry's shift of market focus. Competition is forcing the reduction of prices for both processors and memory, therefore major industry participants are seeking to distinguish themselves in other, more profitable areas.

It is interesting to note that traditional hardware companies are deriving as much as 90% of their profits from software and services. "Network services" is characterized as an enormous growth market, with many customers seeking to outsource network management and data base centers. Even the highest of the high tech players are pursuing opportunities in data base management and associated services. Many hardware firms have shifted their marketing efforts to emphasize the integration of a commodity they sell with open network services offered by a wide range of vendors. Conversely, increasing pressure is being brought to bear on the computer-info-communications market by the entry of several aerospace firms. As DOD budget reductions displace more and more aerospace workers, parent companies are aggressively marketing their expertise in systems engineering.

Greater competition for systems engineering, software, and services markets will give impetus to the drive for a general deregulation of the industry. The RBOCs are no longer prevented from entering selected new markets and have formed strategic alliances with industry leaders. Many industry executives see a silver lining in the trend since "improved productivity through the computer environment" is what they sell.

The good news for customers is that increased competition will drive the cost of information system engineering down. The declining cost of computer hardware and software will open doors to those who haven't enjoyed access to the telecommunications and information systems arena. Increased commoditization of the market place will even further reduce systems integration prices.

Training services will be another growth area. Service providers will offer products via a telecommunications network that will allow students to enjoy the convenience of remote attendance. Most companies believe that industry's help in applying technology is a key to future profitability.

In a final note on outlook, the following illustrate near-term innovations which are likely to have a major impact on industry participants.

- Virtual Reality/Synthetic Environments for a "fly before you build" capability.

- Direct Broadcast TV, an ongoing effort to deliver 150 television channels to the home via satellite.

- A personal telephone that goes with you everywhere.

- Autonomous agents/electronic secretaries that "learn" your preferences and respond for you, as you would.

- Fiber-to-the-Home, a concept that would allow unprecedented amounts of in-home information access- including as many as 500 TV channels.

- Personal computer to personal computer video teleconferencing.

- Digitized voice mail which prioritizes messages.

## INDUSTRY STRATEGIES FOR SURVIVAL

Although there is intense internal competition as well as considerable competition from Europe and Japan, the United States is the only country experienced in all aspects of the telecommunications and information industry, to include development, production and manufacturing. In an attempt to remain competitive, many corporations are changing their basic focus. The key requirements for corporate survival and growth are: public recognition as a world-class company in performance and management, wide acknowledgement as a world leader in all core competencies, and achievement of consistent, continuous profitability.

### Technological Advances

The industry is fast-paced and characterized by innovation and change. American companies recognize that they must push the technological envelope and are investing heavily in research and development (R&D) in order to remain competitive. The American businesses visited during the course of this study have generally increased their R&D investments to 12 - 30% of revenues. Japanese companies are investing similar amounts and have been for a number of years.

***Fiber Optics*** Fiber optic cable is becoming increasingly important as a carrier of data. A small strand of fiber can carry orders of magnitude more data than currently may be transmitted over copper wire. American companies are aggressively exploring means of taking economic advantage of fiber optics. The most popular scheme at present is to establish "fiber-to-the-curb" service throughout the U.S. until market demand for personal and business services requiring these high data rates is defined.

In contrast, the Japanese have established a national policy to provide universal high data rate service (using narrow band ISDN) on their existing copper wire system and already offer this service to 97% of their homes and businesses, in spite of the fact that its actual use is still minimal. As in the U.S., Japanese businessmen expressed a desire to have the government further invest in fiber optics and route it all the way to the home. The capital

expenditure required for "fiber-to-the-home" is far in excess of any single company's resources.

***Super Computing*** Large, mainframe computers seem to have a secure albeit declining spot in the market place. Work stations and personal computers will remain incapable of handling huge data bases at least for the next few years. The U.S. is the leading mainframe producer, however there are indications that Japan is making inroads to the market. One American reply to the Japanese threat is to turn to vector parallel and massive parallel processing using commodity components as a means to maintain an advantage.

***Semiconductors*** Recognizing the relative weakness that American industry has had in semiconductor production, some companies have increased their efforts to regain the lead. U.S. companies are attempting to set new industry standards through the development of new high density processing chips. Engaging in a relatively risky venture. these companies are betting large amounts of capital and possibly the company's future on the new chip. New fabrication plants for these new chips can range in cost from 500 million to one billion dollars--for a chip that will be replaced in two to four years.

***Open Systems*** Increased competition has encouraged a change in philosophy for many American corporations. Previously, the emphasis was on proprietary systems, a scheme which created profitable monopolies for some companies. Today, the entire industry is moving toward open systems in recognition of the fact that it is impossible for one company to be the very best in manufacturing every product. This move is slowed because of the global nature of the industry and the inherent difficulty of protecting intellectual property rights in the international marketplace.

Development of open systems hardware and software is viewed as the key to success. Virtually all of the businesses visited have placed emphasis on the creation of open systems solutions to current interface problems. These businesses are seeking to establish a systems architecture and develop applications that can successfully overlay any number of operating systems and a multitude of hardware platforms.

**2. A Potpourri of Strategy**

A number of other strategies have emerged in support of American industry's desire to remain viable in the information and telecommunications market. A representative sample of them are:

- Offer commercial, off-the-shelf items (COTS).
- Increase automation (decrease head count).
- Stress quality management.
- Seek joint ventures and strategic alliances.
- Encourage government funding of advanced projects.

- Gain competitive advantage through customer financing.
- Support environmental initiatives.

### Innovation and Timeliness

Finding new uses for the evolving digital telecommunications infrastructure is a common theme for American companies. Using data compression to increase information flow through twisted pair cable is one example. Alliances between local telephone and cable TV companies to provide the consumer with vastly increased information and entertainment access is another example. All companies visited expressed the need to reduce the time between product concept to shipping through the adoption of standardized software engineering practices.

## GOVERNMENT RESPONSE

Telecommunications and information systems represent thriving and expanding American industries. Technological innovation is everywhere and the market is characterized by many players and intense competition. Fast-paced technological change has led to reduced product cycle times, constant product innovation, and the adoption of flexible production methods.

The industry is also characterized by a relatively large turnover of employees within the business as well as the rapid rise and fall of businesses themselves. Unpredictable global business cycles also contribute to the industry picture and tend to generate pressures which lead to calls for government regulation. As is currently the case, corporations will continue to call for trade protection from foreign corporations and greater access to foreign markets.

In this dynamic and complex industry, U.S. Government involvement can significantly influence the viability of American firms in the world market, as well as the degree to which the national quality-of-life can be affected by applicable technological advances. In order to make the most of the opportunities afforded by this environment we recommend the following actions:

1. Modify the Federal acquisition system to take advantage of this fast-paced industry. Specifically, repeal and revise those laws and regulations that slow the pace of the procurement process, such as the 1965 Brooks Act. Revisions should truly allow the Government to acquire and use the latest, most effective technology. American companies can successfully compete in a fair market and the budget cannot support the weight of equity at the expense of efficiency.

2. Cooperate with industry to develop meaningful, workable, timely standards. The key to open systems is creating an environment where each new technology can be successfully integrated into a seamless national architecture.

3. Deregulate the cable television and telecommunications industry. The government should allow the telephone and TV cable companies to compete for home information systems

markets in an environment free of federal interference. Market forces driven by competition and innovation should set the course of these services.

4. The government should put in place controls which ensure the protection of individual privacy. Greater access to information allows the unprecedented compilation and integration of personal data. Government must get ahead of this phenomena.

5. Continue to work with foreign governments to develop international regulations and enforcement mechanisms to protect intellectual property rights. As this industry becomes more and more services oriented, ideas become the most valuable commodity of all. Those who develop the ideas must be protected.

In summary, this industry is realizing the intense pressures which represent the best and the worst of a true market economy. Market regulation is demanding and brutal. Survivors will be those that maintain competitive advantage by leveraging product, process, and innovation. The government's role should be tied to standards development and enforcement. It should keep an eye on any emerging monopolies with a view towards future action and it should set the trend for the efficient use of telecommunications and information systems products and processes.

# INDUSTRY STUDIES

# # 11

# Railroads and Trucks

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## PARTICIPANTS

### Students

LTC Dean Cash, USA

Col Glynn Cavin, USAF

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LTC Bruce Dikeman, USA

Ms. Diane Frasier, D/A

CDR Dick Gallagher, USN

CDR Howard Glassman, USN

CAPT Don Hefkin, USN

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LTC Bob Kubiszewski, USA

LTC Joel McGrady, USA

CAPT Spuds McKenzie, USN

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Col Bill Schless, USAF

Mr. Bill Wark, FEMA

CAPT Charlie Wurster, USCG

### Faculty

COL Ed Fortunato, USA

COL Bill Idell, USA

COL Gary Leeling, USA

Col Joe McCue, USAF

## PLACES VISITED

### Domestic

| | |
|---|---|
| Amtrak Passenger Railroad | Washington D.C. |
| Norfolk Southern Railroad | Norfolk, Va. |
| ConRail Railroad | Pittsburgh, Pa. |
| Overnite Trucking Company | Richmond, Va. |
| Burlington Northern Railroad | Texas |
| AHR Trucking Company | Texas |
| Trinity Industries | Texas |
| United Parcel Service | Texas |
| Fleetline Trucking Company | Texas |
| Union Pacific Railroad | Texas |

### International Trip

| | |
|---|---|
| French National Railway (SNCF) | Paris, France |
| French Ministry of Transportation | Paris, France |
| Swiss National Railway | Bern, Switzerland |
| Swiss Meterguage Transfer System | Langenthal, Switzerland |
| Swiss National Railway Training Center | Neiderbipp, Switzerland |
| Swiss Army Vehicle Depot | Bergdorf, Switzerland |
| Italian National Railway | Rome, Italy |
| NATO Defense College | Rome, Italy |
| The Italian Trucking Association (ANITA) | Rome, Italy |
| Arcanes Brothers Trucking Company | Collefero, Italy |
| Frosinone Trucking Company | Collefero, Italy |

**"Victory is the beautiful, bright colored flower. Transport is the stem without which it could never have blossomed."**

**Sir Winston S. Churchill**

## OVERVIEW

This report takes an in-depth look at the railroad and trucking industries in the United States. The report addresses the structure, conduct and performance of each of these two critical U.S. industries.

Industry literature, lectures and discussions with both government and private sector industry leaders, and visits to railroads and trucking facilities at various locations in the United States, and Europe provided the information for our study and analysis. A list of the places we visited, and the experts that visited ICAF to brief the seminar are on included on pages 11-4 of this report.

Rather than consider only the defense aspects of the industries, this report looks at total industry health and the adequacy of the surface transportation system as a national asset. If the transportation system is sound and robust, it will meet the defense needs of the American people.

## INTRODUCTION

The U.S. economy relies heavily on its highly efficient and technologically advanced transportation system to remain competitive in the global marketplace. Our industry study group looked into the performance and business practices of railroad and trucking companies - big and small, foreign and domestic.

Our industry study began at Amtrak headquarters in Washington D.C. with executive briefings, maintenance facility tours and a Sunday ride to Philadelphia on Amtrak's impressive X-2000 passenger train - a 135 mph trip that increased our knowledge of and appreciation for the potential of high-speed commuter rail. On a trip to Norfolk Southern Railroad's corporate headquarters, seminar members were briefed by top executives with a twist on Southern's particular way of doing business. In Pittsburgh, the group boarded an observation railcar for a scenic trip to Harrisburg with briefings enroute and a stop off tour of CONRAIL's "world class" maintenance facility in Altoona.

Following a day trip to Richmond's Overnite Trucking Company, a leader in the less-than-truckload (LTL) industry, the seminar departed for a week of visits to rail and trucking firms in Fort Worth, Texas. During the week, seminar members toured Burlington Northern and Union Pacific Railroads, Trinity Industries, Fleetline Trucking, United Parcel Service and AHR, a small trans-ship company.

Next, seminar members departed ICAF on an international trip to Europe where we compared operating procedures and business strategies of leading European firms to those of

our own rail and trucking industries. In France, we toured transportation facilities and agencies, and rode from Paris to St. Pierre des Corps at 187 mph on the TGV (Train a Grand Vitesse) - the world's fastest train. In Bern, we learned about Switzerland's extensive rail system and "rode the rail" in the Alps. In Rome, we were briefed by Italy's leading trucking association, and toured their most successful truckload (TL) and less-than-truckload (LTL) companies.

This semester the seminar members learned that U.S. rail and trucking industries are "world class" and highly competitive. Since deregulation in 1980, railroads have consolidated, reorganized and prospered, while trucking companies have cut prices, expanded, searched for niche markets, and engaged in fierce competition with rail (and each other) to haul almost 80 percent of U.S. freight. Passenger service, on the other hand, has not yet turned a profit, but is a national priority. Finally, the group learned that vision and quality are not limited to high tech industries, and that U.S. rail and trucking industries are modern, capable, competitive and ready to haul our freight in the 21st century!

## RAIL INDUSTRY

### Structure

The railroad industry groups railroads into three classes: Class I railroads consist of companies with revenues over 250 million dollars; Class II between 20 and 250 million dollars; and, Class III less than 20 million dollars, respectively. There are 13 Class I companies, including Amtrak. Collectively, they employed 222,000 workers in 1992. There are 30 regional railroads, 276 independently owned local railroads, and 199 switching and terminal railroads. These three groups employ 25,105 people. The seven largest companies accounted for 70 percent of the total revenue, with the top three earning over 50 percent.

All competition is "domestic" as there are no foreign railroads in the United States. Buyers number in the millions, representing a true free market. The Department of Defense (DoD) is a minor customer for the railroads. Even with the large movement of equipment during Desert Shield and Desert Storm, the excess capacity of the railroads was only partially affected. The largest single commodity carried by the American railroads is coal. Other major commodities are farm products, chemicals and automobiles.

The most significant barrier to entry into the rail industry is initial investment in equipment and infrastructure. Because of the very high cost of land and other capital assets, it would be very difficult to start a major rail company from scratch. Many of the major rail companies merged in the early 1980's (after the Staggers Rail Act), but that trend has slowed somewhat. Most new entrants to the industry are short line railroads that have purchased tracks from the major companies. They offer improved service to the customer, feed traffic to the major lines, and operate with much lower overhead costs.

### Conduct

***Pricing and Deregulation.*** We must first look at the basic cost structure of the industry. The cost structure of the railroads have to two basic components of total costs of operation: Fixed

costs and variable costs. Fixed costs (or constant costs) are expenses that do not vary with the quantity or volume of business a firm produces. Variable costs will change as a function of the volume of output produced by the firm. Prior to 1980, the entire system of railroad freight rates, labor practices, and even equipment and trackage, were regulated by the Interstate Commerce Commission (ICC). The ICC approved and published freight rates as formal tariffs. These tariffs varied depending on the origin, the destination, and the type of cargo.

The justification for regulation is to protect the customer and the supplier. But, many believed that over time, regulation of the railroads actually caused their decline. As a railroad sank, its rates would go up; leading to less business and a downward spiral. Lacking adequate returns on investment, the condition of rail's physical plants deteriorated seriously. Tracks got to be in such bad shape in the 1970's that a new term was invented: "standing derailment." This could occur when stationary rail cars fell off decrepit tracks. Faced with the alternative of nationalizing the railroads at a cost of over $100 billion or losing most of the country's rail service, Congress eventually deregulated the industry.

Congress enacted Public Law 96-448, commonly known as the Staggers Rail Act, in 1980. It deregulated all railroad rates where the shipper had access to alternative carriers. In 1980, that amounted to about two-thirds of the railroads' business. By 1987, 80 percent of the business was unregulated, with only 20 percent remaining "captive" to a single railroad. The Act permitted the railroads to negotiate contracts with shippers and generally carry on normal business relationships.

Deregulation is what enabled the American railroads to recover and become profitable. Had government continued to regulate the industry in the same way it had been prior to Staggers, railroads would likely have continued their decline until all that remained was a core of bulk commodity traffic that had no alternate carrier.

The obvious benefits to shippers came directly in the form of reduced rates. From passage of the Staggers Rail Act in October 1980 through year-end 1986, rail freight rates, adjusted for inflation, have actually **declined by 4.9 percent**.

In the deregulated environment, railroads now may easily cooperate and contract with other modes of transportation to improve the efficiency and service of the industry. In reality, the railroads remain regulated to some extent, but the amount of regulation is markedly reduced. For the portion of railroad business that government still regulates - shipping rates - rates are set between a "floor" and a "ceiling." Deregulation has served the country well in the time since the Staggers Rail Act. The United States has achieved an integrated transportation service which is cheaper, faster, and more reliable.

***Labor.*** Wages and other labor-related expenses are the largest component of railroad operating costs, accounting for over 40 percent of these expenses. Since 1950, the work force has declined from over one million employees to approximately 250,000 in 1991. Over 80 percent of rail employees are unionized and are represented by 14 major unions.

Rail workers are very well paid, averaging $16.50 per hour, with annual pay and benefits between $47,000 and $54,000 per year. Part of this high pay results from archaic pay rules, including "indian pay" and getting a full day's pay for each 108 miles traveled.

Labor and management have quickly settled most recent labor disputes, partly because of custom and partly because government usually activates the Presidential Emergency Board (PEB) to arbitrate a binding settlement. For example, as a result of a 1991 strike agreement, for employees working on-board trains, the PEB recommended an increase in the basis of a day's pay from 108 miles to 130 miles. An agreement that will be fully in effect by January 1, 1995. Of note, in 1991, a one-day rail strike cost the U.S. economy over $50 million.

Railroads have reduced some labor costs through buy outs and early retirements of employees, however, this action has resulted in a three-to-one ratio of retirees to active railroaders. This rising number of beneficiaries and declining employment is now the focus of a Congressionally-mandated study commission.

***Government Intervention.*** The National Grange, a farmers group numbering over a million in 1870, sponsored the first attempts at railroad regulation. Cheap Chinese labor and free land encouraged over building of track that led to overpricing and vast inefficiency.

Congress had been wanting, at least partially, to nationalize the railroads for breach of public trust. The Act to Regulate Commerce, passed in 1887, created the ICC and gave it broad, independent powers. Its mandates were to enforce rules of common sense as applied to the rail common carrier service. Interestingly, the railroads also welcomed regulation as it helped ease the pain of competition.

The 1906 Hepburn Act gave the ICC power to prescribe maximum rates and made its decisions binding. World War I and the industry's inability to coordinate itself led to the rail industry's nationalization from 1917 to 1920. The Transportation Act of 1920 re-privatized the railroads and attempted to restructure the industry. Next came the Transportation Act of 1958 that provided $500 million in loans for needed capital improvement. Following this, The Northeast Regional Rail Reorganization Act of 1973 (the 3R Act) responded to the bankruptcy of the Penn Central and six other railroads in the northeast. It authorized $2.1 billion of federal expenditures and created two organizations: The United States Railroad Association (USRA) and Conrail. The USRA was to determine what routes to abandon in the northeast, and Conrail became the new, "for profit" railroad — a "phoenix" that would rise out from Penn Central's ashes.

The Rail Revitalization and Regulatory Reform Act of 1976, or the 4R Act, followed next, providing $6.4 billion in railroad aid. The Rail Passenger Service Act of 1970 (RPSA) created Amtrak.

No law has had the impact on the rail industry, or so greatly amended the Interstate Commerce Act, as has the Staggers Rail Act. The main reason is that railroad deregulation did not focus as much on lowering prices as it did for the trucking and airline industries. Rather the strategy for rail deregulation was to improve railroad profits - plain and simple. Where the railroad was not the majority carrier, the new ICC rules set no maximum rates. Railroads could also now enter into binding, confidential contracts. This spirit of reform also allowed abandonment of track and greater merger ability.

***Freight Subsidies and Safety.*** In the mid-1800's, approximately 70 railroads received 130.4 million acres of land under the land grant program. By selling the land, railroad companies

generated operating and development capital. Public Law 102-388 granted $700 million in federal funds for FY93 Amtrak use; $331 million for operating purposes and the remainder for capital acquisitions and improvements.

Until creation of the Department of Transportation (DoT), three federal agencies were involved with the regulation of rail safety. They were the ICC, the Department of Commerce and the Department of the Interior. The Rail Safety Act gave the Federal Railroad Administration (FRA) broader powers in establishing track and equipment safety standards.

In 1992, the FRA issued major rules in three critical safety areas: The first regulation requires railroads to report instances of grade crossing signal system failures; the second specifies safety standards to protect workers on railroad bridges; and, the third establishes new certification requirements for locomotive engineers. These policies will require further investment in equipment and personnel, however, management and government also anticipate improvements in rail safety and overall operating efficiency.

The FRA is continuing safety research on hazardous materials tank car safety, as well as various projects on human factors, such as stress and fatigue and alcohol and drug use; equipment and component failure prevention; locomotive crash worthiness; signals, train control, and grade crossings; and rail integrity.

***Research and Development.*** Steady improvement in quality service and aggressive implementation of new technologies have both regained lost markets and captured new markets once dominated by the trucking industry. The primary areas of research and technology development include car scheduling, advanced train control systems, and new locomotive technology.

High speed rail transportation research is exploring ways for conventional trains to go faster and looking into new electromagnetic train technology. Two different technologies using magnetic levitation (maglev) are currently under development. One, called attraction—or electromagnetic suspension (EMS) maglev technolog—employs conventional iron core electromagnets; the other, called repulsion—or electrodynamic suspension (EDS) maglev technology—employs super-conducting magnets. Both systems rely on electromagnetic forces to provide support (levitation), lateral guidance, propulsion and braking, without direct physical contact between the vehicle and the guideway.

Maglev has numerous advantages over steel-wheel on rail technology, including: low track and vehicle repair and maintenance costs; enhanced safety; less vibration and noise; energy efficiency; less pollution; and, higher speed capabilities (50-150 mph faster than conventional high-speed rail).

The success of high-speed rail in Japan and Europe has generated significant government and private interest, and expedited the introduction of fast passenger trains to the U.S. market. Since shorter travel times are a premium, especially for commuters, Amtrak is leading the U.S. rail industry's efforts to expand high-speed rail

service. It began operating the Swedish X2000 high-speed train for scheduled Metroliner service in February 1993. The X2000 offers car body tilt technology that allows 30-40 percent higher speeds through curves than are possible with conventional train equipment. Amtrak's testing of European high-speed technology will continue with the debut of the German Intercity Express (ICE) in June 93. Other technological improvements include:

● **Advanced Railroad Electronics System (ARES).** ARES is one of two basic systems the rail industry is developing to improve safety and efficiency through a new generation of train dispatching, communication and control. Global Positioning System (GPS) satellites transmit the precise location and speed of freight trains to small on-board computers, all linked to a control center in St. Paul, Minn. The central computer constantly calculates what it would take to stop the train and can actually order a "remote intervention," setting the air brakes to stop the train if the engineer fails to act in time. Besides avoiding collisions, ARES offers other ways to improve productivity. These include: Directing trains to meet at exact times, a factor that saves fuel and maximizes railcar utilization; calculating new operational plans for the entire railroad within 30 seconds after a break down; and, keeping track of crew work hours for the payroll computer.

● **Automatic Equipment Identification (AEI).** This is a mandatory program which requires tagging of all rolling stock in interchange service by the end of 1994. This program reportedly increases productivity through error-free bills of lading, more timely processing of data, computer audits of freight bills, speed-up in cash flow and immediate identification of untagged cars.

● **Steel Wheel Redesign.** Steel wheel redesign is a low stress, curved plate wheel that eliminates premature thermal damage, reduces risk of derailment, lowers fuel consumption and prolongs rail life. The industry could realize an overall productivity gain of approximately $131 million through investment in this single design improvement.

● **Road Railer.** Road Railer is an intermodal trailer concept that continues to provide the flexibility of trucking with the reliability and economy of rail service.

***Intermodal Movement of Containers and Trailers.*** Railroaders consider double-stack equipment as perhaps the single greatest technological breakthrough since the introduction of the diesel locomotive or the radio. Double-stack and piggyback trains offer many advantages over conventional long-haul truck shipments. These benefits include: reduced fuel consumption, less pollution, less highway congestion and less wear and tear on the nation's infrastructure. Intermodel arrangements are now common among all major trucking and rail companies. Industry analysts project continued growth in this highly profitable mutual merger.

Intermodalism is big business in the railroad industry. Intermodal traffic doubled from 3.1 million trailers and containers in 1980 to 6.2 million in 1991. More than 100 double-stack trains depart from the west coast weekly. Double-stack cars now account for 30 to 35 percent of total intermodal capacity.

Intermodalism is also efficient: The Department of Energy reports that railroad intermodal service (truck-trailers and containers) is up to two-and-one-half times as fuel efficient as motor carrier service, so a shift from highway to rail will mean less imported oil.

**Performance**

The heavily regulated, domestic rail industry of pre-1980 was a non-customer oriented oligopoly with a declining share of the transportation market. Deregulation changed that.

With 80 percent of rail traffic deregulated, rates fell 28.8 percent. Farm and coal product rates fell 42 percent and 19 percent respectively. While prices declined, market share stabilized and rates of return increased. The industry's consolidation and downsizing made it more competitive both within rail and with the trucking industry.

Revenue from intercity freight traffic is at its highest level ever. Industry revenue (measured in per ton mile) is at an all time high reaching $1.39 billion in 1991. Passenger trends are also up, with Amtrak intercity travel topping six million miles for 1991.

***Profitability.*** In 1991, the rail industry generated nearly $31 billion in revenue. Revenues in 1992 increased about 3 percent to nearly $32 billion. The industry-wide operating ratio is around 91 or 92, affording rail a relatively good profit margin of 8 percent, with most of the major railroads earning a profit margin in "double-digits."

***Quality of Products and Services.*** Total Quality Management (TQM) and customer surveys have become standard in the rail industry. Sante Fe created a new customer quality and support center as part of its company-wide reorganization to focus on customer needs. CSX Transportation and Conrail created customer service centers to quickly assist customers with rate quotes and provide instant updates on the location/status of their goods. By most accounts, rail's stabilizing market share and increasing revenues would indicate that the industry's emphasis on quality and customer service is paying off. In another service-related initiative, Amtrak is teaming with the U.S. Post Office using Road Railer technology to establish an intermodal postal system capable of overnight delivery of mail. This teamwork promises improvements in postal service nationwide.

***Cost of Products.*** Labor is railroad's largest component of operational cost. As employer buy outs continue and the retirement pool declines, this cost will shrink.

The revitalization of rail has caused Class I companies to spend heavily in upgrades. In 1993, Norfolk Southern is projecting expenditures of $565 million in new capital investment. Amtrak has budgeted $200 million this year for the Northeast High Speed Rail Improvement Project (NHRIP).

***Future International Expansion.*** Industry and government officials expect the North American Free Trade Agreement (NAFTA) to have a profound effect on the rail industry. Mexico, in particular, is a fertile place to expand service. Nearly all of the U.S. and Canadian carriers — Union Pacific (UP), Santa Fe, Burlington Northern (BN), Southern Pacific (SP) — have initiatives in place to strengthen their bonds with Mexican rail. These initiatives range from investing in infrastructure such as a bulk grain rail port at Torreon, to leasing motive power, to Santa Fe assuming logistical responsibility for all Ford Motor Plant Mexico operations. In addition, UP and SP have built major intermodal facilities near the Mexican Border. UP has recorded an 18 percent growth of intermodal cargo each year since 1990.

Changing markets may also require carriers to change the type of rolling stock they operate. For instance, NAFTA may increase the North/South traffic in finished goods - rather than the current traffic consisting primarily of raw materials. This would result in a greater need for boxcars rather than flat cars.

## TRUCKING INDUSTRY

### Structure

The trucking industry is substantially different in structure than the railroad industry. These differences can be summarized as follows:

- Rights of Way. Highways are public structures, virtually all of which are government financed, with free and open access granted to all citizens. Railroads are privately built and maintained with access limited to the owning railroad or to other railroads to whom access is specifically granted.

- Industrial Structure. Commercial motor transport has few natural barriers, either financial or structural. Ownership of a single vehicle is enough to enter the business. Railroad transportation has always required ownership of a large physical plant, thereby restricting entry into the industry to all but those enterprises large enough to own and operate the necessary rights-of-way, rolling stock, and maintenance facilities.

***Motor Carrier Industry.*** Next, we will focus on the commercial movement of freight only, commonly called the Motor Carrier Industry. Motor carriers can be structured into two broad categories — private and for-hire. For-hire carriers can be further subdivided into common, contract, and exempt carriers. These categories are defined in the following paragraphs:

- Private Carriers: Private carriers are those who carry their own products in their own trucks. Their trucking activity must be incidental to or in furtherance of their primary business. There are in excess of 100,000 private carriers, of which almost 15 percent are manufacturers and distributors of food products. Private carriers are a significant national asset that decision makers often overlook because of the lack of visibility that the private carriers have in most government reporting systems.

- Common Carriers: Common carriers are the firms we normally think of as "the trucking industry." They are firms that hold a certificate of convenience and necessity from the ICC, and transport general cargoes on an as-needed basis. There are two basic categories of common carriers, truckload (TL) carriers that haul freight loads that "fill up the truck" - usually in excess of 10,000 pounds, and less-than-truckload (LTL) carriers that haul freight loads less than 10,000 pounds. Truckload carriers usually travel direct from the shipping point to the point of destination, while the LTL carriers use distribution terminals for hub and spoke operations. In fact, the larger common carriers operate extensive networks of terminals to consolidate and distribute their LTL lots of manufactured items - this is their primary business. In fact, LTL firms currently maintain the greatest market share of the trucking industry - about 32 percent as compared to TL's market share of about 20 percent.

- Contract Carriers: Contract carriers are similar to common carriers except that they contract their services to a few large shippers.

- Exempt Carriers: Some 11 categories of motor carriers were exempted from economic regulation under the Motor Carrier Act of 1935. By far the largest of these are the carriers of agricultural products — an exemption that the farm lobby obtained and still maintains. There are currently over 50,000 exempt carriers operating from one to several hundred trucks.

In today's marketplace, there are over 265,000 motor carriers. Of that number, over 150,000 are individual owner operators. Like rail, buyers number in the millions, allowing for a free market system. In 1991, 47,890 ICC regulated carriers generated $78.3 billion in revenues; $36.9 billion in revenues, or nearly half, was generated by the top 100 carriers. Similar to government involvement with the railroads, the DoD plays only a minor role in the total revenue generated by the industry.

As stated earlier, entry barriers in the trucking industry equate to the cost of a truck - about $95,000 for a new tractor and as low as $30,000 for a used late model

tractor. A complete rig (tractor and trailer) costs about $115,000 new, but many firms use their own trailers and employ for-hire tractor owners to pull their equipment. These low barriers to entry are readily evident when you consider the tremendous number of sellers in the marketplace. It also accounts for the great excess capacity available for defense requirements.

**Conduct**

***Pricing and Deregulation.*** As with the railroad industry, prior to 1980, federal and state governments regulated trucking industry rates, labor practices, routes and equipment. Deregulation, especially at the federal level, has changed the way our trucking companies do business. Major transportation related fixed costs include license fees, property taxes, salaries of supervisory and senior management, and terminals. Variable costs include wages of hourly employees, depreciation of vehicles based on usage, repairs and maintenance costs, fuel, lubricants, insurance, and so on. As with the railroads, labor costs constitute the major operating expense of the trucking industry - about 52 percent of industry-wide operating expenses are for labor costs.

Unlike the rail industry, that is heavily weighted with fixed costs, the cost structure of the motor carrier industry is much more heavily weighted with variable costs. Therefore, the total cost structure of the industry is responsive to the volume of shipping traffic. Because of the nature of motor carrier costs, carriers are often restricted in their ability to reduce rates below a certain level - because of their variable costs, there are limits below which individual firms can no longer reduce rates to meet their competition. Since for-hire carriers compete with other modes of transportation **and** with the private carrier, the rates a for-hire carrier charges must be related to and competitive with the cost of providing private carrier service.

Prior to 1980, the ICC managed federal regulations that focused on price rather than quality of service or customer satisfaction. Petitioning the ICC for entry became one of the toughest ways to enter the trucking industry. Buying a firm already in the industry was the easiest. Unfortunately, this system did not enhance competition or efficiency. From 1950 to 1975, the volume of goods shipped via truck increased three fold. Nevertheless, due to the difficulties in entering the market, the number of regulated carriers declined 20 percent during the same period (19,597 to 16,005). This pricing policy kept inefficient carriers operational.

Like the Staggers Rail Act, the Motor Carrier Act of 1980 reduced the power of the Federal Government in regulating rates. Motor carriers now have a far greater ability to set rates independent from ICC interference. Pricing has become a direct function of competition within the market structure.

***Labor.*** Unlike the railroad industry that must deal with 14 separate unions, the

primary union in the trucking industry is the International Brotherhood of Teamsters, Chauffeurs, Warehousemen, and Helpers of America (Teamsters). Currently, there are approximately 200,000 teamster members working in the LTL segment of the industry. Since deregulation, a significant decline in union membership has occurred. This equates to a loss of over 160,000 members, or 45 percent of total membership.

This decline has come about for two reasons: Deregulation and better management practices. Prior to 1980, since carriers received immediate freight rate increases from the ICC based on increased labor costs, management readily accepted union wage and benefit demands. With deregulation came an almost immediate increase in the number of motor carriers - a virtual flood of new firms entered the market - consequently, competition increased significantly and freight rates dropped. Those unionized carriers with high labor rates were no longer able to compete. In fact, teamster organized carriers have accounted for approximately 90 percent of the major truck line bankruptcies since 1980. After the Motor Carrier Act, the unions could no longer pass their outrageous demands for wage and benefit increases on to the consumer.

Today's deregulated environment has brought about a dramatic change in the attitude of Teamster leaders. This change in attitude has manifested itself at the bargaining table. Secure jobs have taken the place of higher wage and benefit demands. American Trucking Associations (ATA) statistics indicate the average hourly earning for truckers has increased from $9.33 in 1980 to $11.72 by 1990. These averages vary widely within the industry with union drivers in the LTL business making more than the industry average. Still, a trucker has to drive a lot of miles to make the $47,000 to $54,000 per year his railroad counterpart earns.

Better management practices also played a major factor in controlling unionization. Today's trucking management has embraced the concepts of TQM, and some firms are actually doing TQM to improve processes and service. This "quality focus" was evident in our discussions with senior managers at Overnite Transportation Company and Fleetline Trucking.

**Government Intervention.** The primary government intervention in the trucking industry takes place in the area of safety. The agency responsible for this action is the Federal Highway Administration (FHWA), an arm within the Department of Transportation (DoT). The FHWA establishes minimum levels of insurance and safety requirements, requiring compliance that includes: inspection of trucks, every two years, medical examination of truck drivers, testing drivers for illegal drugs and alcohol abuse, monitoring drivers' log books, and regulating the movement of hazardous materials. Additionally, the FHWA has established a requirement for a nationwide Commercial Drivers License (CDL) program, a key feature of current federal safety enforcement efforts. Its purpose is to ensure that truck drivers of commercial vehicles

have only one license and that they are qualified to operate their vehicles.

**Research and Development.** As in the rail industry, technology in trucking has also been improving man-machine interfaces. Lighter, more fuel efficient tractors, trailers that support heavier loads, and more durable engines have served to increase productivity in the industry. Also, anti-lock brakes, traction control systems, cruise control, air suspension seats and noise reduction cabs have enhanced safety.

Another change is intermodal transportation. Historically operating as competitors, rail and trucking firms are now forming intermodal, seamless operations that provide the low cost of long-haul rail while matching the high service level of the trucking industry. Transportation studies have shown that at between 600 and 700 miles of "haul," it is more efficient to ship by rail. For haul distances less than this, trucks seem to be more competitive. Accordingly, intermodal operations are natural reactions of the market seeking efficiencies and economies.

Today's truckers are also taking advantage of technological advances in the communications and computer industries. Some examples of these advances include:

- **Space Division Multiple Access.** This technology greatly enhances the number and quality of channels available for two-way mobile communication. Developers project it to be a low cost 24 satellite system that should be affordable to even the smallest firms.

- **Satellite Tracking and Global Positioning.** Trucking firms are using these technologies to monitor hazardous material shipments. An expansion of this technology will involve the use of "brilliant containers" that will communicate with satellites through transponders. This will also enhance "in transit visibility."

- **Nationwide Transportation Radiotelephone Service.** This is a cellular communication technology that employs ground based stations instead of satellites.

- **Electronic Data Interchange (EDI).** On-board computers are available to provide near instantaneous EDI. Information such as billing, invoicing, shipment status, estimated times of arrival and maintenance reports is now available to managers and customers on a real-time basis.

- **Intelligent Vehicle and Highway Systems.** The FHWA is sponsoring "smart highway" program technologies. The system combines computerized traffic control and routing systems with on-board computer driven guidance systems to optimize traffic flow and minimize congestion.

**Performance**

Before 1980, fewer than 20,000 for-hire carriers held ICC operating authority. Only a small percentage of carriers held 48-state authority, and contract operating authority was limited. By July 1992, the number of ICC regulated motor carriers was nearly 50,000 with 17,000 carriers holding 48-state authority. In addition, various third parties operating in the industry, especially ICC licensed brokers, have been affecting the intensity of an already competitive market. Brokers have been matching shippers with carriers, thereby increasing available customer choices and pressuring carrier margins. The net effect has been a marked increase of ICC licensed brokers from about 100 in 1980 to more than 7,200 in 1992. ICC freight forwarders have tripled from around 200 in 1980 to 663 in 1992, further adding to the competition.

According to Traffic World, June 1992, trucking companies were going out of business at a record pace. The industry-wide failure rate was higher than the general business community. *Dunn and Bradstreet* took a look at the top 100 U.S. carriers in 1980 to determine their current status. The result was that most of these companies had gone out of business or been sold to the remaining few. A look at federal deregulation over the past decade clearly shows that the "Big Guy", over time, was able to survive the adjustments.

***Profitability.*** In 1992, the trucking industry generated an estimated 281 billion dollars in total revenues, accounting for 77 percent of the total U.S. freight market. This represents five percent of the nation's Gross Domestic Product (GDP).

The financial performance of the trucking industry improved slightly in 1992 after disappointing years of 1990 and 1991. Excluding the United Parcel Service (UPS), the entire ICC 100 large carrier group had revenues totaling $22.1 billion, but a net income of only $314 million in 1991. This resulted in a net profit margin of only 1.4 percent, compared with historical norms closer to 2 to 2½ percent. Indicators published recently by the ATA projected a net profit margin of 2.44 percent and an overall operating ratio of 95.6 (down from 96.5) for the first nine months of 1992. Unfortunately, much of this projected gain was offset by a less than profitable fourth quarter. Collective industry profits for 1992 ended at only 1.8 percent.

***Quality of Products and Services.*** Successful companies emphasize efficiency, cost control and quality of service. A prime example of this is J.B. Hunt Transport Services. Through a cooperative effort with Santa Fe Railway, Hunt and Santa Fe have combined the cheaper fuel and labor of trains with the faster and more reliable services of trucks. Intermodal service is rapidly gaining popularity throughout the trucking and rail industries, as well as with the customer - the shippers.

***Cost of Products.*** Rising operating costs are attributed to increased expenses in acquiring and maintaining equipment fleets and terminals; increased labor cost, especially due to the current shortage of drivers, and the added requirement for training and retraining their drivers; and, the costs associated with stricter federal and

state enforcement of environmental laws and regulations.

***Future International Expansion.*** Expansion into foreign markets could benefit the trucking industry. The trucking industry does acknowledge a global economy and the emergence of major trading blocks, North American Free Trade Agreement (NAFTA) and the European Economic Community (EEC). While the U.S. motor carriers transport cargo throughout Canada, our relationship with Mexico is limited. Mexico restricts the entrance of U.S. motor carriers and drivers. In order to do business in Mexico, U.S. firms have formed partnerships with Mexican companies. This same restriction does not apply to Mexican companies in the U.S. Once signed into law, NAFTA will eliminate many existing restrictions.

The trucking industry also anticipates substantial growth in the European market — estimates are that a 60 percent growth will occur by the year 2000. Trucking companies want to play a role in shipments originating in Europe enroute to the U.S. Several firms are forming alliances with European firms, while others are trying to establish companies in Europe.

## INDUSTRY OUTLOOK

The structure of both the railroad and trucking industries has changed dramatically since deregulation. Inefficient companies are rapidly being forced out of business. In the trucking industry minimal entry barriers are allowing more carriers to enter the marketplace. While entry barriers are significant in the rail industry, deregulation has allowed shortline railroads to proliferate as never before. The firms that will be successful in the 1990's and in the next century are those that will take efficiency to the maximum.

Within the trucking industry the short-term outlook is not good. A general profit squeeze on motor carriers will continue in 1993. Railroad cost cuts and efficiency gains will add to downward pressure on trucking rates, and a tight supply of qualified drivers will force labor expenses higher. Greater access to intrastate markets, modest growth in the economy, and streamlining of regulatory paperwork should offset the profit squeeze somewhat. The comprehensive application of information technology will facilitate an expansion of service, and further blur distinctions among operators in the various freight modes.

In the long-term, trucking will remain the dominant freight mode in this country, but multi-national shippers and sophisticated global freight carriers will increasingly determine which firms haul the freight. The improved global logistics capabilities of many carriers — motor, rail, water, and air — affirms the importance of understanding global production and distribution. The application of world class information systems

will be critical in this highly competitive market. The companies that stay abreast of these technologies will eclipse those that do not.

In the short-term, experts forecast modest growth in the rail industry and project that both ton-miles and passenger-miles will increase by three and seven percent respectively. Experts expect intermodal traffic will be the fastest growing area of the transportation industry, increasing by three to five percent in tandem with the increasing importance of container and double-stack service.

In the long-term, experts anticipate rail tonnage and passenger-miles to grow by 1 to 1½ percent, and 2 to 3 percent, respectively, per year. Freight traffic, however, is heavily dependent on the strength of industrial production.

## STRATEGY FOR SURVIVAL

Within the trucking and rail industries, survival strategy for individual firms revolves around cutting operating costs and increasing market share. The current emerging technologies and efficient traffic management will provide the tools to improve the timeliness and quality of service to the customer, as well an opportunity to reduce administrative costs.

Efforts like increasing the size of payloads (such as triple-double bottom and larger trailers), increasing intermodalism, greater travel time for drivers per week, reduced crew sizes on trains, technological advancements that improve fuel efficiency, and customer support are only a few actions that may take place in order for these two industries to become more competitive in the global marketplace. Developments like NAFTA and the EEC cooperative economic arrangement, and the increase in globalization of trade, should further help the rail and trucking industries.

## GOVERNMENT RESPONSE/RECOMMENDATIONS

The cost of compliance with government regulations is skyrocketing, costing both industries billions of dollars in taxes and in compliance with rules and regulating requirements. Government leadership must standardize and streamline federal, state and local regulations. Specifically, intrastate regulation of the transportation industry must be brought into the 21st century and mirror interstate regulation. This will allow for greater profit margins and place the trucking and rail industries on a more even footing.

Since transport is essential for our national economic security, government needs to assist in productivity improvements. This assistance should come in the form of government guaranteed private loans, or government matching public funds with

money raised by private investors.

Specifically, the foundation of the nation's transportation system is its infrastructure - highways, bridges, terminals and other fixed facilities. The 21st century presents formidable challenges to the U.S. highway system. One negative aspect of our expanding trucking business is the wear and tear to our highways. Because of the increased use of highways and roads over the past 20 years, our highway infrastructure is deteriorating at a faster rate than originally expected. In many regions it is nearing the end of its service life and major rehabilitation is needed. It is estimated that 40 percent of the 557,000 U.S. bridges are structurally deficient, with a repair bill estimated as high as 100 billion dollars. Additionally, more than 60 percent of the 3.9 billion miles of highway require replacement or major repair. President Clinton has recognized the deficiencies in the U.S. infrastructure and has proposed programs to correct these deficiencies.

We have several recommendations for revisions to U.S. national policy regarding the rail and trucking industries: First, DoT should review both the indirect and direct subsidies given to rail and trucking. The perceived advantage is that the trucking industry is not paying its fair share to use the highway infrastructure, compared to the rail industry which must pay for maintenance of its rights-of-way. This perceived advantage is not borne out when the profit margins of both industries are examined - rail is making money, trucking is operating on the margin.

Regarding rail subsidies, the government needs to continue to invest in improving and expanding passenger rail service. In particular, joint government and private investment in high speed magnetic levitation systems and/or high speed passenger rail systems is needed to improve commuter transportation service. Further, the federal government should reduce subsidies to Amtrak, and Amtrak should use these government subsidies to improve efficiency and profit margins with an eye towards zero subsidies in the future. Using subsidies to pay for operating costs instead of for capital investment needs to stop.

Second, U.S. transportation policy should encourage intermodal operations to capitalize on the efficiencies inherent in the two industries where there is a natural market for both trucks and trains. Intermodal firms that connect land, sea and air modes of transportation are able to capitalize on the short haul flexibility of the truck and the long haul efficiency of rail. These intermodal operations are the type of transportation system that the country needs for the future.

Third, the rail and trucking industry should exploit the opportunities of the NAFTA, and the industry and government should encourage teaming with European transportation firms. NAFTA serves to eliminate many existing restrictions between the U.S. and Mexico. Our highly competitive rail and trucking firms will benefit from expansion into foreign markets.

## CONCLUSION

In every war and national emergency, our highly developed and redundant transportation system — trains and trucks — has met the dual challenges of supporting mobilization requirements while continuing to carry the essential traffic of the world's largest and most diverse economy. The excess capacity has always been there and after our review, we believe, will continue to be there in the future.

This future appears to hinge on three developments: First, we must adopt President Clinton's plan to refurbish our transportation infrastructure. Second, the railroads must continue to modernize their labor agreements, reduce their work force and invest in the future. Finally, both industries must work together through intermodal relationships that capitalize on the inherent efficiencies of each mode of transportation to allow each system to do what it does best.

# INDUSTRY STUDIES

# #12

# AIRLIFT / SEALIFT

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## PARTICIPANTS

### Students

Lt Col Brad Baker, USAF

LTC Ed Bishop, USA

Mr. Keith Boi, DOT

LTC Phil Campbell, USA

LTC Tom Cash, USA

Lt Col Phil Davidson, USAF

CAPT Rick Davis, HHS

LTC George Deason, USA

Col Buster Diggs, USMC

LTC Russ Garrett, USA

CDR Bob Hammond, USN

CDR Don Hoffmann, USN

Col Duncan McNabb, USAF

LTC Glenn Melton, USA

Lt Col Barry Smith, USAF

Mr. Greg Sweetland, D/A

LTC Dennis Williamson, USA

### Faculty

CAPT D'Arcy Roper, USN

Col Larry McCourry, USAF

Col Bill Holbrook, USA

# PLACES VISITED

## Domestic

| | |
|---|---|
| Baltimore-Washington International Airport | BWI, Maryland |
| Federal Express Facility | BWI, Maryland |
| Dover Air Force Base | Delaware |
| *Cape Horn* Fast Sealift Ship (FSS) | Norfolk, Virginia |
| 7th Transportation Group | Fort Eustis, Virginia |
| James River Reserve Fleet | Fort Eustis, Virginia |
| Seafarers International Union (SIU) Maritime Seaman School | Piney Point, Maryland |
| Forces Command (FORSCOM) J-4 | Ft. McPherson, Georgia |
| Delta Airlines | Atlanta, Georgia |
| Hartsfield International Airport | Atlanta, Georgia |
| Lockheed Aerospace Systems Company | Marietta, Georgia |
| Military Traffic Management Command (MTMC) - Eastern Area Headquarters | Bayonne, New Jersey |
| Military Sealift Command (MSC) | Atlantic Headquarters |
| Newark International Airport | Newark, New Jersey |
| Port Authority | New York and New Jersey |
| SeaLand Inc. | Port Elizabeth, New Jersey |
| American President Lines (APL) | South Carney, New Jersey |
| US Merchant Marine Academy | Kings Point, New York |
| Federal Express | Memphis, Tennessee |
| LITCO lighter aboard ship (LASH) terminal | Memphis, Tennessee |
| Blount Island Command Marine Corps prepositioning facility | Jacksonville, Florida |

## International

| | |
|---|---|
| MTMC-Europe | Rotterdam, Netherlands |
| Europe Combined Terminals | Rotterdam, Netherlands |
| Rotterdam Harbor Control Commission | Rotterdam, Netherlands |
| Ned Lloyd | Rotterdam, Netherlands |
| KLM airlines | Amsterdam, Netherlands |
| Maersk Lines | London, England |
| British Chamber of Shipping | London |
| Bain Clarkson Ltd. | Lloyds of London |
| Royal Fleet Auxiliary | London |
| Infrastructure and Logistics Division, British Ministry of Defense | |
| Heathrow Airport Authority | London |
| British Airways | London |

# INTRODUCTION

***Deterrence is only credible if we possess a robust means of power projection and the mobility to deploy and sustain our forces.***

**General Colin Powell**
**Chairman, JCS**

Since 1989, there have been unprecedented changes in international political affairs. Most notable have been the end of the Cold-War and the demise of the Soviet Union and Warsaw Pact. In light of these changes, the American public and politicians have demanded significant reductions in the United States Armed Forces. These national Defense reductions, or the so-called "peace dividends," are needed to combat domestic economic problems.

But these reductions in national defense have implications aside from the obvious economic ones. As our Armed Forces become smaller, we will experience a disproportionately larger reduction in forward deployed forces. Given that the world is still a dangerous place and that the United States still has worldwide interests, we will have to depend, more than ever, on force-projection capabilities. Airlift and sealift - both civil and military - will be essential to this force projection strategy. This paper provides an assessment of the U.S. airlift and sealift industries and identifies major issues which challenge the ability of the United States to develop the overall airlift and sealift capability needed to support the national strategy.

## PART ONE - AIRLIFT

***Any consideration of a balanced force is incomplete without consideration of strategic lift. The ability to project power rapidly must be guaranteed....Such a structure must allow us to project strategic land forces directly and rapidly from the Continental U.S. into areas of vital interest...We are currently on the margin in responding to short-notice robust contingencies, a margin that will evolve into a major deficiency in the next 5 years if sea and airlift capabilities do not improve substantially.***

**General Edwin H. Burba, Jr.**
**CINCFORSCOM**

Airlift provides the quick reaction side of strategic mobility. It is both fast and flexible, allowing the United States to project power into any corner of the globe. To meet its wartime airlift requirements, DoD relies on both military and civil aviation. Lessons from the Gulf War and recommendations of the *Mobility Requirements Study* all stress the need for a robust

strategic airlift capability. This part of the report will first examine the commercial aviation industry and then assess organic military airlift capability.

## CIVIL AVIATION INDUSTRY

Since the Civil Reserve Air Fleet (CRAF) is the civilian component of our strategic mobility, the health of the U.S. airline industry will continue to be important to national security strategists and military planners.

### STRUCTURE

The U.S. commercial airlift industry as defined by the Standard Industrial Classification Manual consists of three industrial groups: scheduled air transportation services, Standard Industrial Classification (SIC) Code 451; non-scheduled air transportation services, SIC 452; and airports, flying fields, and terminal services, SIC 458. The scheduled air industry includes companies providing cargo and passenger transportation services over regular routes and on regular schedules (SIC 4512) and establishments providing air courier services for individually addressed letters, parcels, and packages (SIC 4513). Non-scheduled air transportation includes those establishments providing cargo and passenger charter service including sight-seeing services, air taxi services, air ambulance services, and helicopter couriers (SIC 4522). The airports and terminal services industry includes those companies providing airfields, aircraft service facilities, freight and passenger handling services, and privately operated air traffic control facilities (SIC 4581).

Because of their contributions to CRAF, national security strategists are primarily interested in the scheduled airline industry group. Currently, there are 213 air carriers in the United States; 178 provide scheduled passenger service; 9 provide scheduled cargo-only service; and 26 provide charter services. Of the 178 that provide scheduled passenger services, only 22 operate aircraft with 60 or more seats and generate revenues in excess of $100 million. These 22 airlines account for 95 percent of the total revenues for scheduled passenger services. The remaining 156 scheduled airlines are designated as regional carriers.

**Concentration.** Since the late l980s, the U.S. scheduled passenger airline industry has experienced a wave of mergers. Today the industry is highly concentrated with the top four companies earning 66 percent of the total operating revenues (as of 1991). These top four airlines are United, American, Delta, and Northwest. The cargo-only market is highly concentrated as well. While the top two cargo-only carriers (United Parcel Service and Federal Express) represent less than 10 percent of the top 25 airlines by total operating revenues, they own over 70 percent of the cargo market share.

**Barriers to Entry.** Barriers to entry are one reason for the high concentration within the airline industry. These barriers include: expensive capital investments; limited access to hub and spoke systems; and erratic and spiraling fuel costs. The biggest capital investments are aircraft. Aside from initial investment costs, aircraft have approximately a 25 year life cycle and must be replaced. Government regulations require new aircraft to be safer and quieter. The industry need to increase profitability dictates more fuel-efficient aircraft. These factors, coupled with general inflation, have caused the cost of new aircraft to spiral upward.

Computer systems used to plan route structures, track reservations, and schedule aircraft maintenance services are also significant capital investments. While air traffic has doubled since the early 1970s, no new major airports have been constructed (with the singular exception of Denver's new airport now under construction). New facility construction is expensive, time consuming, and plagued with environmental issues. In 1989, jet fuel prices were 58 cents per gallon. In 1990 following Iraq's invasion of Kuwait, fuel prices nearly doubled to $1.14 per gallon.

**CONDUCT**

The dominant pricing policy in the scheduled airline industry since the mid-1980s has been widespread discount pricing. Airlines have resorted to this technique in response to steadily falling traffic, particularly in regard to domestic travel. Given that route structures, schedules, capacity, and costs for a particular flight are fixed well in advance, airline discount pricing strategy presumes that seats filled at 50 or 60 percent of the full fare rates are better than seats not filled at all. Discount pricing policies have dominated the industry for so long that most discretionary travelers are now unwilling to pay full fares. Therefore, discount pricing will continue to be the trend for the foreseeable future. Air carriers must aggressively pursue other operating efficiencies and productivity improvements. To the consumer, this will mean cuts in routes, frequencies, and services.

**Government legislation**. Chapter 11 protection of weaker carriers has exacerbated the poor profitability of the airline industry. Debt relief allows bankrupt carriers unfair advantage by allowing them to cut their fares below actual overall costs. The stronger carriers must follow that lead to protect their market share, and the entire industry loses. The overall health of the commercial industry requires that the market be able to cull out unprofitable carriers. Legislation should be changed so Chapter 11 carriers do not have a competitive edge in an industry which already suffers from overcapacity.

Since 1980, Government legislation of the industry has proliferated largely due to safety and environmental concerns. Much of this legislation, although currently pending enactment, is expected to have significant long-term implications for the industry. The Airport Noise and Capacity Act of 1990 will require the replacement or upgrade of 54 percent of the total jet fleet by December 1999.

The Aviation Safety and Capacity Expansion Act of 1990 authorized the Federal Aviation Administration (FAA) to grant authority to airports to levy a $3.00 fee on passengers that would be used to improve airports. This act is expected to be beneficial to the industry in that it would ultimately expand access to gates and facilities, thereby promoting competition.

In response to public concerns over airline accidents, the FAA is expected to issue new directives relative to structural and corrosion standards. These directives will result in costly modifications and maintenance for approximately one-third of the existing commercial jet fleet and significant cost increases in manufacturing new aircraft.

**Large Capital Investment Forecast**. Investment in the airline industry is expected to continue for the forseeable future. In 1990, the total jet fleet had 4,252 aircraft. Allowing for aircraft retirements, the FAA estimates that the fleet will expand to over 5,500 aircraft by 2001.

This translates into a 2.4 percent annual growth rate and gross deliveries exceeding $200 billion. Despite the recent dismal financial performance of the industry, these deliveries will be used to expand capacity as well as comply with noise abatement and structural legislation. The industry's poor financial performance, coupled with its already huge debt burden (currently estimated at 2.9 times equity) will make the financing of new aircraft difficult.

This results in a dilemma for an industry which is a critical part of the national defense. To obtain needed capital, a recent trend in the airline industry is for domestic carriers to turn to foreign carriers for investment in return for part ownership in the company (enhancing their ability to expand into the U.S. market). Northwest Airline's partnership with KLM (Dutch) and USAIR's recent merger with British Air raise concern about the future CRAF participation of these companies.

**PERFORMANCE AND OUTLOOK**

Since 1989, passenger carriers in the U.S. airline industry have generally experienced huge financial losses while cargo-only carriers have earned profits. In 1989, passenger carriers showed a $942 million dollar profit and in 1990, a $820 million dollar loss. This loss trend continued in 1991 and 1992 and significant losses are forecast for 1993. These losses can be attributed to the U.S. economic recession, high fuel prices, rising debt service costs, and the adverse effect of the Persian Gulf War on international air travel. In 1990, airline revenues increased 4.8 percent over 1989, but unit costs increased 10.7 percent (largely due to the increase in jet fuel costs).

In contrast to domestic markets, international traffic for U.S. airlines has increased by over 60 percent in the last four years. The highest growth overseas market is in the Pacific area which has increased 22 percent annually since 1986 and is forecast to continue its high growth into the next century.

The future outlook for the industry is encouraging. Recent reports of modest growth in the economy are reasons for optimism. The FAA has forecast that domestic traffic will increase at an annual rate of 4.1 percent through the year 2001 while international traffic should increase annually at a rate of 6.4 percent.

**Enhancing Airport Operations.** A most important and increasingly complex element of the airline industry is airports. During our visits to airports both in this country and Europe, four common challenges surfaced repeatedly - throughput, the environment, noise, and security. Airport administrators, both civilian and military, compromise and juggle the four to function efficiently and effectively.

Throughput involves multiple means of access for both passengers and cargo. Airports must be located adjacent to major road and commuter arteries. Atlanta's Hartsfield International Airport planned and constructed a rapid transit terminal a full five years prior to the city completing its rapid transit system. Washington's National Airport is serviced by rapid transit and eventually Dulles International Airport must be connected as well. This trend for better transportation network interfaces must continue if overall transportation efficiencies are to be realized.

Environmentally, jet fuels, cleaning solvents, deicing solutions, and hydraulic fluids must be dealt with by both military and civilian airfields. As flight volume increases, so does hazardous material waste. Construction of elaborate collection facilities and waste treatment plants all add to the price of an airline ticket.

Although the environment includes noise, noise rates separate discussion. Noise problems are costing both airports and airlines billions. Typical of many airports around the country, Hartsfield Airport was either buying land and houses or paying to insulate homes close to flight paths. The Boeing 727, the backbone of domestic flights, is too noisy for most airports. A costly re-engineering of newer models or early retirement of older models are the only options currently available to airlines to meet noise levels. Quieter MD-80/90s or 757s represent millions in premature aircraft acquisitions.

Throughput and security are in many ways mutually exclusive. Airport officials want easy access, quick passenger processing, and minimum inconvenience to the paying customer. Security managers, for good reason, often impede this process. Airports, both military and civilian, are surrounded by high fences with controlled access points beyond passenger drop-off areas. In addition to the recent requirement of X-raying hand-carried luggage, an increasing percentage of hold stowage luggage will be X-rayed. Long lines will continue at passenger access points to the departing gates. All these requirements add cost to the airports and airlines which will eventually flow to the passenger and freight customers.

**Civil Aviation Manufacturing**. Civil aviation manufacturers have been lobbying President Clinton about the dire state of their industry. With increasing debt and high unemployment, the future may include more layoffs from the high paying and high technology jobs that are so important to long term national prosperity.

Civil aviation manufacturers contribute significantly to the U.S. economy with a strong trade balance. Boeing's sale of aircraft to other countries alone amounts to four percent of total U.S. exports. However, during the last several years, aircraft manufacturers have watched as economic hard times have engulfed their industry. Airline orders for new aircraft are down 50 percent. Other orders have been canceled or pushed back. This affects many other high technology industries, exacerbating the drag on the economy. When Boeing or McDonnell Douglas announces layoffs, you get the domino effect from support industries such as Pratt and Whitney which recently announced a layoff of 10,000 workers.

The stakes are enormous as Europe tries to increase its market share even in the face of declining sales. Additionally, Japan, Taiwan, and the Community of Independent States have shown interest in trying to break into the market, either through joint ventures or by going it alone.

The row between the United States and Europe over Airbus (Europe's number one civil aviation manufacturer) intensified recently when President Clinton stated "a lot of (the proposed Boeing) layoffs would not have been announced had it not been for the $26 billion that the U.S. sat by and let Europe flow into Airbus over the last several years." Airbus, subsidized by four governments, has indeed broken the American monopoly on building commercial airliners, moving past McDonnell Douglas into the world's number two position.

President Clinton is under tremendous pressure to help American manufacturers. In a speech to Boeing company employees in February 1993, he promised to spend about $8 billion on new investments in aeronautics and technology. The plans calls for spending over the next five years, and may be enough to keep the United States in the leadership role during the next generation of commercial airliner development.

We agree that this is a good idea given the fierce global competition that has already begun. Aerospace companies need the boost in new money to develop new technologies to take on giant consortiums like Airbus. Congress needs to approve the infusion of money into civil aviation manufacturing. This would provide excellent return on investment - saving high technology jobs, stimulating the economy, and allowing the United States to continue its position as the world's leader in civil aircraft manufacturing.

**Civil Aviation Contributions to DoD - the CRAF.** In 1952 the Department of Defense created the Civil Reserve Air Fleet as a program through which commercial airlines would identify aircraft and crews to support mobilization requirements. In exchange, DoD offered peacetime charter contracts to commercial airlines who voluntarily participated in the program. CRAF was activated for the first time during the Gulf War. The Military Airlift Command activated 38 commercial aircraft in August 1990 and the Secretary of Defense activated an additional 187 aircraft in January 1991. These CRAF assets delivered 22 percent of the total air cargo (115,000 tons) and 69 percent of the passengers (334,000) to Saudi Arabia. To the extent the Gulf War can be used as a guide for planning future strategic deployment requirements, it is clear that CRAF will have a significant impact on future U.S. force projection capabilities. Despite the success of the CRAF concept in DESERT SHIELD/STORM, the first *ever activation* also identified problems which must be addressed. Two significant challenges to the CRAF program warrant further discussion.

The first challenge is how to compensate airlines - that are becoming more global in nature - for loss in market share to a non-CRAF participant if future activation occurs. This loss may be to a foreign international carrier. The United States would be hard pressed to discourage such business practices and unable to penalize the carrier that benefitted from the need to requisition CRAF aircraft.

Secondly, adjustments to the CRAF program must be made as DoD commercial airlift business decreases in proportion to the defense drawdown. To entice airlines to remain in the CRAF program, new incentives must be offered and disincentives eliminated. Discussions with individual airlines and industry trade representatives surfaced unique incentives that may increase participation and obstacles that must be eliminated to enhance activation.

First, DoD could link peacetime government business with an airline to its share of CRAF participation. To ensure adequate numbers of militarily useful aircraft, an investment tax credit can be tied to the initial purchase of specified airframes. Government business with each airline should be consistent so long term acquisitions and schedules can be developed by airline planners. Finally, DoD can authorize CRAF participants to use military bases for commercial activities, technical stops, or weather alternatives; this could be particularly enticing if allowed overseas.

DoD must also remove disincentives from CRAF contract agreements when activated: FAA waivers for aircrew flying time restrictions and maintenance cycles must be automatic; notification time must be lengthened (from 48 to 96 hours); and DoD must assume insurance liability for activated aircraft and crews.

USTRANSCOM is currently negotiating a new CRAF contract with commercial carriers. Results of these negotiations need to be monitored by future Airlift/Sealift seminars.

**Overall Industry Forecast.** In the long term, the U.S. airline industry can recover from the huge operating losses experienced in the early I990s. However, in the short term, the industry will continue to experience mergers, consolidations, and bankruptcies. The industry pricing policy of using discount fares will continue while other operating and productivity efficiencies are sought. Internationally, marketing agreements between U. S. and foreign-flag carriers will expand and promote increased competition. Despite its problems, and if recommended CRAF incentives are adopted, the airline industry should continue to be able to provide adequate lift to augment organic military capability to support the national strategy.

## MILITARY AIRLIFT CAPABILITY

There is broad consensus that the United States must maintain a preeminent airlift capability. In the last 20 years, the National Command Authorities have turned to airlift as a means to further U.S. national interests more often than any other part of our military. As the most responsive and flexible leg of the mobility triad, airlift always plays a crucial role in any deployment, especially the initial stages.

**The Only Choice For Immediate Response.** When President Bush made the decision to send troops to Saudi Arabia on 7 Aug 1990, the strategic airlift force of C-5s and C-141s began the deployment, kicking off an airlift that would grow to 127 aircraft landing in theater daily, averaging an arrival every 11 minutes. Within 24 hours, F-15 fighters from the First Tactical Fighter Wing and the initial contingent of the 82nd Airbome Division were in place in Saudi Arabia, drawing "the line in the sand" to deter further Iraqi aggression.

The importance of airlift to the initial deployment cannot be overstated. The first Maritime Prepositioning Ship (MPS) from Diego Garcia did not arrive until six days later and the first fast sealift ship from CONUS did not arrive for an additional 13 days (20 days after the President's decision to deploy).

As the world continues to shrink and reaction times become even shorter, airlift will be even more crucial to the National Strategy. Indeed, former Secretary of the Air Force, Donald B. Rice, remarked to the Washington chapter of the National Security Industrial Association on 1 Mar 1990:

> Airlift is more than movement of troops and cargo. It strengthens security partnerships, offers disaster relief, and allows the United States to influence events impacting the national security. It projects America's power - and America's concem.

## MODERNIZATION

Unfortunately, the current airlift force of C-141s and C-5s is old and technologically dated. Growing operation and support costs are a major symptom of aging aircraft and indicate the need to modernize. The higher number of personnel to maintain and crew older systems and the increased spare parts requirements are simply no longer affordable. Just as major airlines replaced serviceable 727s and DC8s with more efficient 757s and MD11s, so too must the United States modernize its airlift fleet.

Additionally, the constant demands on airlift have simply worn out the workhorse of the fleet - the C-141. On 17 May 1993, General Fogelman, CINCTRANS, ordered immediate limits on the use of the aging C-141 due to cracks in the wing structure. This followed numerous similar restrictions on the aircraft over the past several years for other structural problems. Therefore, modernization is not only smart, it is ***essential*** to rebuilding airlift readiness in the United States.

**C-17 - The Right Airlifter at the Right Time.** Numerous studies, including the recent *Mobility Requirements Study*, have verified the C-17 as the most cost effective and militarily useful solution to strategic airlift needs. It will not only provide essential modernization, but will also allow "direct delivery" to austere airfields, cutting out time-consuming intermediate staging stops. Additionally, its superior ground maneuverability will increase cargo throughput at congested destination airfields.

The C-17 was designed around the lift U.S. forces need and the force structure it is to join. Technology has allowed building a strategic airlifter with true tactical capabilities allowing its efficient use across the spectrum of conflict. In peacetime, its efficiency will allow the Air Force to replace the C-141 as the workhorse of the fleet. During conflict it can provide superb strategic airlift capability. After sealift is fully underway, the strategic airlift requirement goes down, and the theater airlift requirement goes up. If required, the C-17 can swing to a theater airlift role and augment the theater C-130s (leaving the remaining strategic flow to the CRAF and C-5s). Simply put, the C-17 will make the entire airlift fleet more efficient and allow deployment and employment options which simply do not exist today.

In addition, the C-17's lower manpower requirements and reduced operating costs make it the perfect replacement for the C-141 as DoD's primary peacetime airlifter. The C-17 is over twice as efficient as the C-141. State of the art, economically maintainable, and extremely effective, the C-17 will change the way airlift does business.

Virtually every Service Chief and every CINC has strongly supported the need for this aircraft. The United States needs to get on with building the C-17s at economical production rates and keep the production line open until all C-141s and some of the older C-130s are replaced. If the National Command Authorities are to have the transportation options they need to meet the challenges of the future, the nation needs this airlifter.

## AIRLIFT SYSTEM INFRASTRUCTURE

When modern Cassandras warn of a hollow force, we generally infer a problem with training, munitions, and spares. A similar concern must be the ancillary infrastructure of the

airlift system. Investment in C-17s will not guarantee true capability unless all necessary support equipment is also obtained. There are two current areas of concern - pallet usage and numbers, and adequacy of material handling equipment (MHE).

**463L Pallets.** During DESERT SHIELD/DESERT STORM we experienced a critical shortage of 463L pallets and associated netting. Roughly 1000 pallets were shipped to the theater each day while the average return for the first 140 days was 115 empty pallets per day - usually without the accompanying nets. Major aerial ports were reduced to only a two-day supply on hand. In fact, the shortage became so critical that in January CENTCOM established recovery teams to scour the theater (albeit with little noticeable effect). By that time less than 35,000 of 148,000 pallets (including 20,000 newly procured) could be accounted for.

Where were all the pallets? Much has been made of the bunkers roofed with 463L pallets, but the great majority of the missing pallets were "absorbed" by the "system." Herein lay a misconception of the planners: the 463L pallet is not merely a convenient mode of air cargo shipment; ***it is a container in its own right and part of an intermodal system.***

Properly rigged pallets conveniently hold cargo in neat packages (netted containers) providing organization and storage. They also keep the cargo "containerized" and easy to handle for ground transportation from the aerial port of debarkation to the unit in the field or the theater depot. Pallet and net inventories had been based on an assumption of a 25-day turn around. Obviously, this turn around did not materialize.

An understanding of the system - through education and training - will help to form the discipline needed to make the system work. From better understanding of the full systemic use of pallets to recycling empties, awareness is a cheap alternative to buying the huge excess inventories current abuses require.

In-theater infrastructure needs are currently being evaluated by TRANSCOM and the Army Combined Arms Support Command. Additional 463L pallets (25,000 were purchased with Japanese Gulf War contributions) have already begun strengthening airlift capability, with a new goal of 200,000. And a ninety-day turn-around is being studied for use as a new planning factor.

**MHE.** The general health of material handling equipment (MHE) is improving. Air force authorizations are currently filled to 83 percent with slated improvement to 90 percent by 1996. Deliveries of over 1500 new 10K standard and adverse terrain forklifts will be completed this year, and delivery of 231 new 25K loaders is well under way. Delivery of 1000 4K and 6K forklifts will begin later this year. Much of the replaced equipment will be moved to fill vacant WRM requirements.

Two additional critical MHE assets require special attention. The first is the aging 40K loader - the workhorse of the MHE fleet. Built with 1960s technology, they are running with an 18 hour MTBF rate, and 163 of 283 (58 percent) are suffering from severe metal fatigue and structural cracks. The 40K loaders are slated to be replaced by the 60K loader currently under development. Two competing prototype machines will begin testing this year with deliveries of 360 loaders to be made between 1995 and 2000. The 60K loader will carry up to

six 10,000 pound pallets (vice the four of the 40K), will be able to service all cargo aircraft from the C-130 to the B-747, and is required to operate with a 100 hour MTBF rate.

The second critical area is wide-body (essentially civil or civil-based) cargo loaders. The biggest part of the solution, of course, is the 60K loader as it is designed to reach the high cargo decks of wide-body aircraft. Additionally, the Air Force is overhauling its aging and maintenance-intensive Cochran elevator loaders. The Cochran elevator loaders comprise a major portion of the Air Force's wide-body loading capability and, more critically, are the primary deployable wide-body equipment.

The Air Force is also purchasing 30 on-board loaders for the KC-10. Although light duty equipment, these loaders (four for each KC-10 base and one for each fighter wing) provide essential flexibility and quick reaction capability without diverting prime equipment away from larger work concentrations.

## AIRLIFT RECOMMENDATIONS

- Use the market place to cull the overcapacity in the commercial airlines. (The traditional protection afforded by Chapter 11 from debt relief must be modified to preclude giving the troubled carriers unfair advantage.)
- Monitor and control mergers between U.S. and international carriers so they in no way affect participation in, or activation of, the CRAF program.
- Fund R&D in aeronautics technology to ensure U.S. leadership in the civil aviation industry.
- Pursue governmental policies that "level the playing field" in both aircraft manufacturing and commercial aviation. Target artificial barriers and government subsidies in trade negotiations like GATT to ensure fair competition throughout the industry.
- Continue investment in both road and rail access to airports.
- Stretch the compliance dates for noise restrictions. Premature aircraft retirements with the corresponding need to buy quieter, more expensive aircraft is a financial burden.
- Incentivize the CRAF program to keep it viable and responsive to national defense needs.
- Procure the C-17.
- Ensure planning fully encompasses the broader, intermodal nature of the military air cargo 463L pallet (container) system.

- Ensure a robust system capability including fully deployable MHE. Airlift capability is more than aircraft capacity.

## PART TWO - SEALIFT

***It was an absolutely gigantic accomplishment and I can't give enough credit to the logisticians and the transporters who were able to pull this off.***

**General H. Norman Schwarzkopf**

The large-scale deployment of equipment and supplies from the United States to Saudi Arabia in support of Operations DESERT SHIELD/DESERT STORM revealed again this country's heavy dependence on ocean transportation. In total, 95 percent of the cargo needed to support allied forces in the Gulf War was transported by sea. Now, two years later, with the U.S. military restructuring itself into a predominately CONUS-based force, DoD's ability to rapidly deploy equipment and supplies by sea has become increasingly important.

To meet its sealift requirements, DoD relies on both Government owned and privately owned vessels. Based on lessons learned from the Gulf War and recommendations contained in the *Mobility Requirements Study*, Congress has authorized increases in the number of Government owned vessels. As discussed below, however, trends in the commercial sector make DoD's ability to rely upon U.S. privately owned assets far less certain.

### STRUCTURE

DoD uses all aspects of water transportation. Most critical to its ability to deploy OCONUS is the deep sea freight segment (SIC 4412 and 4424), hereinafter called the Sealift Industry.

According to the U.S. Department of Commerce, 200 companies provide deep sea freight service. These companies generate approximately $8 billion in annual revenue. The Federal Government, while a significant user of sealift services for military and food shipments, accounts for a small share of industry revenues (less than 5 percent).

**Concentration.** The sealift industry is highly concentrated. Among companies providing sealift services, the top 4 receive 39 percent of industry revenues. Concentration levels increase further, however, when foreign and domestic liner (e.g., scheduled container service), non-liner (e.g., charter service), and tanker (e.g., liquid bulk) services are viewed separately. In this regard, only six companies, down from 18 in 1970, currently operate five or more ships in the American foreign liner trade. Of these six, American President Lines and SeaLand Service dominate. The number of domestic liner companies likewise is small. The Maritime Administration lists 12 carriers operating in domestic liner service. No more than five carriers operate in any one of the domestic trade routes.

**Fleet Size.** The U.S. oceangoing merchant fleet consists of over 600 privately owned and Government owned ships (see Table 1). These ships have a combined deadweight tonnage (dwt) of 23.0 million tons. Of the 348 privately owned ships in active use, 50 percent are tankers

and 36 percent are intermodal ships (container ships, container barges, Roll-on/Roll-off (Ro/Ro) ships). Most of the tankers (65 percent) operate in the U.S. domestic trade, while most of the intermodal ships (54 percent) operate in U.S. foreign trade.

Table 1
U.S. Oceangoing Fleet - November 1, 1992

| | Number | DWT (000) |
|---|---|---|
| Privately Owned | | |
| Active | 348 | 17,142 |
| Inactive | 37 | 2,369 |
| Total | 385 | 19,511 |
| Government Owned | | |
| Active | 11 | 112 |
| Inactive | 208 | 3,392 |
| Total | 219 | 3,504 |
| Grand Total | 604 | 23,015 |

Source: Maritime Administration. "U.S. Merchant Marine Data Sheet". November 1, 1992.

From 1981 to 1992, the number of ships in the U.S. privately owned merchant fleet (active and inactive) declined by 33 percent (578 ships in 1981 to 385 in 1992). For the same period, deadweight tons decreased by 8 percent (21.1 million tons to 19.5 million), reflecting a trend toward larger ships.

Most of the Government owned ships are part of the National Defense Reserve Fleet. This fleet is administered by the U.S. Department of Transportation, Maritime Administration (MARAD). A special component of the National Defense Reserve Fleet is the Ready Reserve Force (RRF). The RRF currently consists of 96 ships which are activated in 5, 10, or 20 day increments to meet DoD surge requirements. During DESERT STORM, MARAD activated 78 RRF ships. Due to their poor operating condition at the time of their call up, however, many of these ships were not able to meet their prescribed activation on time. Obtaining crews for some of the ships was also a problem.

The world ranking of the U.S. flag fleet is declining relative to that of other countries. In terms of number of ships, the United States fell from 11th largest in 1988 to 16th in 1991. During the same period, the United States fell from 8th to 10th largest in deadweight tons. Overall, the U.S. privately owned merchant fleet comprises 2 percent of the world's total deep draft merchant fleet and 3 percent of the world's deadweight tonnage.

**Barriers to Entry.** Entry into the Sealift Industry is difficult. Barriers include high capital costs, low financial returns, overcapacity, and intense competition from foreign flags (e.g., Maersk, Ned

Lloyd, and Evergreen). In terms of capital costs, the United Nations Conference on Trade and Development estimates that the cost of building a new ship ranges from $24 million for a 15,000 dwt general cargo ship to $52 million for a 2,500 TEU (twenty foot equivalent unit) full container ship. Costs of building a vessel in U.S. shipyards are much higher than in foreign shipyards. The differential has been as high as 55 percent for liner vessels.

## CONDUCT

**Government Involvement.** The Federal Government heavily influences the conduct of the Sealift Industry. The Federal Maritime Commission (FMC), an independent five-person body, regulates liner shipping and U.S. domestic offshore trades. FMC's major regulatory responsibilities include receiving carrier and conference tariffs, investigating restrictive trade practices of foreign governments, and protecting U.S. flag carrier rights to transport cargo in foreign trades. The FMC does not regulate entry or approve rates for ocean shipping.

MARAD is responsible for promoting and assisting the Sealift Industry. MARAD has broad statutory responsibility to foster the movement of commercial cargoes and ensure the existence of merchant shipping in time of national emergency. MARAD's principal programs are (1) providing U.S. flag carriers with operating subsidies (projected FY 1993 Operating Differential Subsidies [ODS] will exceed $245 million), (2) maintaining the National Defense Reserve Fleet and Ready Reserve Force, (3) insuring/guaranteeing payment to lenders financing construction or reconstruction of U.S. flag vessels, (4) monitoring compliance with U.S. cargo preference laws, and (5) operating the U.S. Merchant Marine Academy.

The U.S. Coast Guard is responsible for port safety and security; environmental protection; vessel safety, inspections, documentation, and investigation; and licensing of merchant vessel personnel. In carrying out these responsibilities, the Coast Guard has imposed numerous regulatory requirements on U.S. flag ships, particularly in regard to crews and safety. These requirements are often costly and often not required by foreign governments.

In the aftermath of the Exxon Valdez oil spill off the Alaskan coast in March 1989, U.S. public opinion has been greatly aroused in support of decisive measures to protect the environment. The Oil Pollution Act of 1990 was an outgrowth of the Exxon Valdez accident. Under the Act, shipowners face unlimited liability damages. The Act also requires new tankers over 5,000 gross tons entering U.S. waters to be built with double hulls.

**Cargo Preference/Cabotage.** In addition to regulating and promoting the U.S. flag, the Government has restricted certain cargoes to movement by U.S. flag. The Cargo Preference Act of 1904 requires all cargoes procured for or owned by the military services be carried exclusively on U.S. flag vessels. Similarly, the Merchant Marine Act of 1920 (Jones Act) requires all waterborne commerce between points in the United States to be carried on vessels built in the United States and owned by U.S. citizens.

The United States is not alone in cargo preference and cabotage. The U.N. Conference on Trade and Development's "Code of Conduct for Liner Conference" allows each signatory nation to carry 40 percent of its imported and exported products in its own vessels and 40 percent in vessels of another signatory nation. When this code went into effect in 1983, 56 countries had signed the code. The United States has not signed the code on free trade principles.

**Ratemaking.** The use of conferences is the principal characteristic of ocean carrier ratemaking. Conferences exist in virtually all major trade lanes, and the United States grants antitrust immunity to conference carriers provided they have the right to take independent rate action. Conference carriers dominate all major trade lanes, moving from 50 to 70 percent of the cargo carried.

An exception to the use of conference rates is found in the military procurement of sealift. For military procurement, the Military Sealift Command (MSC) negotiates directly with U.S. flag carriers to obtain rates applicable to military shipments. These rates are normally effective for six months and are published in MSC rate guides. Based on the rates negotiated, the Military Traffic Management Command routes cargo offerings and books cargo on U.S. flag vessels.

**Technology/Innovations.** The U.S. Sealift Industry has been an innovator in world shipping. Developed in the United States, containerization has reshaped the international liner trade. With containerization, average handling time per voyage fell from 157 hours to 31 hours, reducing cargo handling costs by 65 to 80 percent. Along with containerization came massive investments in containers, cranes, new ships, and marshalling areas near ports.

Current industry investments center on improvements in automation, ship propulsion systems, navigation systems (e.g., global positioning systems), and electronic data interchange for cargo documentation. Operational improvements include intermodal transportation services, hub-and spoke operations, and joint ventures. Through these operational developments, water transportation firms are becoming vertically integrated and are providing more point-to-point transportation services. Although these improvements help U.S. flag carriers provide quality service at competitive rates, the accessibility of U.S. markets allows foreign competitors to easily adopt U.S. carriers' innovations.

**Maritime Labor.** With increases in labor productivity and decreases in fleet size, the number of shipboard jobs in the U.S. flag fleet has significantly declined. In 1960, there were almost 55,000 shipboard jobs and over 100,000 active seafarers. By 1990, these numbers had declined to 10,000 shipboard billets and 27,000 active seafarers.

Automation and containerization have reduced the number of people needed to crew a vessel. Modern U.S. vessels typically operate with 21-person crews (some older vessels operate with as many as 36). This is significantly more than what operate foreign flag vessels. The Coast Guard's criterion for establishing minimum manning levels is the safe navigation of that vessel. Typically, that level is 15; however, management decisions and collective bargaining agreements result in higher crew levels.

In addition to larger crews, U.S. carriers face the added burden of paying higher wages than foreign competitors. For example, on a typical 4,000 TEU container ship operating in the Pacific trades with a crew of 21, total wage costs for a U.S. flag operator range from $9,000 to $10,500. This is more than double the $4,200 paid on foreign-flag vessels.

## PERFORMANCE

**Tonnage and Market Share.** During the past ten years, tonnage shipped annually in U.S. deep-sea foreign trade increased from 760.0 million tons (1981) to 822.6 million tons (1990). During the same period, U.S. flag market share remained relatively constant ranging from 3.9 to 5.8 percent. Within deep sea shipping segments, U.S. flag carriers increased their market share in non-liner service from 1.2 percent to 2.1 percent and in tanker service from 3.9 percent to 4.4 percent. U.S. liner service market share, however, dropped from 27.6 percent to 18.6 percent.

Despite regulatory burdens not experienced by foreign operators, U.S. flag carriers have demonstrated their ability to compete in international markets. Among both U.S. and foreign carriers, SeaLand ranks first in market share (15 percent) in the U.S.-Europe/Mediterranean Trade. In the U.S.-Far East Trade, American President Lines ranks first on inbound cargo traffic (14 percent) and second on outbound cargo traffic (11 percent). In this same trade, SeaLand ranks third on inbound cargo traffic (10 percent) and eighth in outbound cargo traffic (6 percent). In the U.S.-Middle East trade, Lykes Bros. ranks third on inbound cargo traffic (19 percent) and sixth in outbouna cargo traffic (3 percent).

**Capacity and Utilization.** The deep sea shipping industry is characterized by overcapacity. During the late 1980s, capacity increased faster than trade growth in each of the major U.S. liner trade routes, causing load factors and rates to fall. In the Transpacific trade, for example, load factors fell from over 90 percent in the mid-1980s to 70-75 percent in 1991. During the same period, rates fell by 30 percent. A recent report in the Lloyd's Shipping Economist indicates that half the total number of container slots in the North Atlantic liner trades are not used. Declining freight rates plague this trade route too.

**Profitability.** Profit levels in deep sea shipping are low. Between 1984 and 1991, return on assets for 16 major U.S. and foreign liner companies averaged from 0.9 percent to 2.6 percent. For the same period, return on sales averaged from 1.1 percent to 2.9 percent. The two major U.S. carriers (American President Lines and SeaLand) showed a net loss from their operations from 1985 through 1988. American President Lines generated profits of $51 million in 1989, a loss of $64 million in 1990, and a profit of $131 million in 1991. Return on assets totaled 0.6 percent in 1989 and 4.6 percent in 1991 (1990 results are not meaningful). SeaLand generated operating profit of $126 million in 1989, $80 million in 1990, and $99 million in 1991. Return on sales totaled 5.4 percent in 1989, 3.0 percent in 1990, and 3.1 percent in 1991. It is interesting to note that of the two carriers mentioned above, SeaLand does not receive Government operating subsidies and yet had higher profits in two of the last three years.

## OUTLOOK

While the U.S. merchant marine has shown itself very capable, the future health of the industry remains uncertain. Competition from foreign carriers remains intense. Overcapacity exists, putting downward pressure on freight rates. Profit levels are low. Major U.S. carriers threaten to register their ships under foreign flags. With changes in the U.S. military force structure creating more dependence upon a viable U.S. merchant marine fleet for deployment, DoD must stay closely attuned to changes occurring in the water transportation industry and play an active role in ensuring its needs are well publicized.

The future performance of the U.S. flag merchant marine industry will depend to a large degree on the future volume of international trade and on the ability of companies to control labor, fuel and other operating costs.

In terms of trade, projections are bright. Overall estimates for 1993 show U.S. imports increasing by 4.2 percent and exports by 5.6 percent. Carriers in the liner trades stand to gain the most with gains of 9.0 percent for inbound cargo and 6.2 percent for outbound cargo. Factors which could further improve trade include a successful conclusion to the Uruguay Round of talks on the General Agreement on Tariffs and Trade, further integration and accompanying economic strength of the European Community, and the continued easing of the international recession.

In terms of costs, prospects are less promising. U.S. ship owners traditionally have been unsuccessful in controlling labor costs. Despite fewer mariners, maritime unions remain strong, making it unlikely that wage concessions will occur any time soon. Additionally, President Clinton's proposed BTU tax will increase fuel costs, causing some ship operators to bunker their ships outside the United States.

A final issue clouding the future of the U.S. merchant marine is the Administration's recently stated position to allow operating subsidies to expire. Without alternative maritime reform, this free market action could be the catalyst that propels the merchant marines' unchecked decline to its final demise.

## STRATEGIES FOR SURVIVAL

The Sealift Industry is pursuing four strategies to sustain profitability:

**Operational Alliances.** To reduce costs, improve service, productively use scarce capital, and share the risks and rewards of the changing international liner shipping market, carriers in the foreign liner trades are entering into joint ventures with each other. These joint ventures include space chartering, vessel sharing, joint sailing schedules, equipment interchange, and joint venture agreements and consortia. Of particular significance, the space sharing arrangements offer carriers the opportunity to offset some of the cost and risk of replacing aging vessels in markets with overcapacity. They also present the possibility that future lift capacity will be achieved through multi-carrier ventures in which carriers order and use ships well in excess of the capacity of today's largest ships. The Port of Rotterdam, Europe's largest port, anticipates additional operational alliances among carriers and is actively planning infrastructure enhancements that will accommodate larger ships and clear cargo through the terminal more quickly. This strategy is sound as wide-ranging operational alliances can achieve significant cost reductions, reduce excess capacity, and improve customer service.

**High Technology Physical Distribution.** U.S. ship operators increasingly see their future in being full service physical distribution companies, capable of managing a customer's just-in-time inventory program, providing high quality, seamless door-to-door intermodal service, and providing timely information. American shipping companies pioneered containerization along with double-stack rail service in the United States and they continue to introduce new technology such as electronic data interchange that improves the logistics of documentation, handling, and tracking cargo. Both American President Lines and SeaLand are continuing to invest in information technology (including automated container tracking) and in other areas to gain competitive

advantage through value added rather than lower rates. This strategy should continue to promote profitability of U.S. carriers.

**Maritime Reform.** To ensure future profitability, the Sealift Industry is actively seeking Government reform of current maritime policies and programs. In April 1993, American President Lines and SeaLand presented a reform proposal to Transportation Secretary Pena. The cornerstone of the proposal called for operating differential subsidies to ocean carriers of between $1.1 billion and $5 billion. The proposal is likely to meet resistance as, historically, consensus among carriers, labor, and shipbuilders has not been achieved and as the Administration has recently indicated it plans to let operating differential subsidies expire.

**Reflag Ships.** A final strategy, being considered by American President Lines and SeaLand, is to reflag ships under foreign registry. In this regard, both carriers have announced that without significant Government subsidy and maritime reform, they will reflag their ships used in the international trades. Reflagging will allow these carriers to operate at a lower cost by avoiding higher U.S. crew costs; using lower cost, foreign-built ships; and avoiding safety and environmental regulations imposed on U.S. vessels. Both carriers have indicated that they will continue to operate in the profitable Jones Act trades (primarily Alaska, Hawaii, and Guam) which require U.S.-flagged, U.S.-owned, U.S.-crewed ships. There may be labor difficulties with this strategy, but if those can be overcome, the strategy should succeed.

## GOVERNMENT RESPONSE

DoD sealift requirements can be broken down into surge (e.g., combat vehicles) and sustainment (e.g., supply) categories. The privately owned deep sea fleet, comprised mostly of tankers and container ships, is currently of limited value to DoD in meeting surge requirements as tankers and container ships are not designed to move large volumes of heavy combat vehicles. The preferred ship for movement of these vehicles is the roll on/roll off (Ro/Ro) ship.

To ensure adequate surge lift, DoD has a number of Ro/Ro vessels in its inventory. Most notable among these are 8 fast sealift ships. These ships were used extensively during the Gulf War. As a result of sealift shortfalls identified in the *Mobility Requirements Study*, however, Congress has appropriated over $3 billion for DoD to acquire 20 additional large, medium speed Ro/Ro ships and two container ships. Eleven of the Ro/Ro ships will be used for fast sealift, while the remaining nine will be assigned prepositioning roles. In all probability, the Ro/Ro ships will be the large, 950-foot variety.

In addition to these acquisitions, the *Mobility Requirements Study* recommended the expansion of the RRF to 142 ships. Most of the expansion will come from additional Ro/Ro ships and additional tankers. Already, twelve additional Ro/Ro ships have been purchased on the open market.

Finally, to correct problems associated with activation of the RRF, DoD and the Department of Transportation formed a Joint Ready Reserve Force Working Group. Recommendations of the Group that are now being implemented include (1) establishing new vessel readiness standards, including vessels on 4- and 5-day reduced operating status, (2) outporting all reduced operating status ships, and (3) conducting sea trials on RRF ships.

Although the military services initially resisted the Sealift Industry trend toward containerization, more and more military cargo, particularly sustainment cargo, is now being moved via container. In light of this trend, privately owned, deep sea container ships are of great value to DoD. If American President Lines and SeaLand reflag their vessels, however, the number of U.S. container ships will decline to 18 by the year 2005.

The risk this decline presents to DoD is whether it will be able to charter foreign flag ships to meet sustainment requirements. During DESERT SHIELD/DESERT STORM, chartering foreign flag vessels was not a problem. Whether it will be a problem in the future will depend on the nature of the conflict and the international alliances formed.

## SEALIFT RECOMMENDATIONS

- Continue DoD acquisition of militarily useful deep sea vessels.
- Maximize use of containers for OCONUS movements.
- Clarify responsibilities for developing in-transit cargo visibility.
- Support a strong and viable U.S. merchant marine.
- Comprehensively reform all aspects of maritime policy vice piecemeal and in isolation (e.g., subsidies apart from crew size, shipbuilding and ownership requirements).
- Establish a merchant marine reserve program.
- Maintain funding for improvements to the RRF.

# INDUSTRY STUDIES

# # 13

# HEALTHCARE

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### Domestic

| | |
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| National Naval Medical Center | Bethesda, MD |
| National Institutes of Health | Bethesda, MD |
| USNS Comfort | Baltimore, MD |
| Ilinois Eye and Ear Infirmary | Chicago, IL |
| Quorum Health Resources, Inc. | Chicago, IL |
| Cook County Hospital | Chicago, IL |
| Baxter Healthcare Corporation | McGaw Park, IL |
| V. Mueller Medical Instruments Corporation | Niles, IL |
| Siemens Gammasonics | Hoffman, Estates, IL |
| U.S. Department of Agriculture | Washington, DC |
| Secretary of Defense (Program Assessment & Evaluation) Washington, DC | Washington, DC |

### International

| | |
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| Royal Army Medical College | London, UK |
| British United Provident Association | London, UK |
| Deputy Speaker, House of Commons | London, UK |
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| Headquarters, 7th Medical Command | Heidelberg, Germany |
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## INTRODUCTION

The United States enjoys the reputation of having the best quality health care system in the world. Health care is one of the largest and most profitable industries in the U.S. economy. However, the U.S. health care system has come under much criticism from both private and public forums for failing to meet the needs of an increasing number of Americans. Cost and access to care are two of the most pressing issues. The industry is made up of a broad composite of education, research, manufacturing, and services. This study concentrates on the industrial aspects of equipment and pharmaceutical design and manufacturing, biotechnology research, health care public policy formulation and decisionmaking, health care administration, and health services.

The U.S. is the world's largest producer and consumer of medical equipment, pharmaceuticals, and health care services. Advances in technology, an aging population, and an inefficient market have combined to increase the demand for health care services and drive up costs.

Since 1980, the Nation's health care expenditures have increased by 400 percent and now represent more than 14 percent of Gross Domestic Product (GDP). Over the last 40 years the health care industry has experienced a real rate of spending of 5.5 percent. The increasing expense of health care has prompted the Federal government to explore new cost containment strategies. It has also inspired state legislatures and private businesses to implement their own initiatives to save money and improve efficiency through such programs as managed care, preferred provider organizations, and non-price rationing schemes. In spite of these efforts, costs continue to rise at a steady rate, and a growing number of Americans are finding themselves priced out of the health care market. Governmental spending on Medicare and Medicaid continues to dramtically increase, contributing to the annual deficit.

These problems have led many public leaders and private citizens to advocate universal access to health care as a fundamental right for all Americans. Others, however, are hesitant to impose government controls that might restrict freedom of choice, compromise the quality of care, or jeopardize technological advancements in the health care industry. Opposing views have formed the basis for a complex and intense debate over health care reform. While an analysis of this complicated issue exceeds the scope of this study, some of the more salient issues underlying the health care dilemma will be discussed. Also, this paper provides a general review of the overall state of the health care industry, and its capacity to respond to natural disasters and national security threats.

## INDUSTRY PERFORMANCE

During the last 15 to 20 years, the health services industry has grown at a vigorous pace and today represents one of the fastest growing service industries in America. However, industry analysts predict that overall growth will slow, particularly for elements of the health care industry that become restrained by the national health care reform. Independent of such

reforms, manufacturing of surgical and medical instruments, surgical appliances, and general medical supplies will continue to experience double digit export growth. One of the most promising areas of industry performance is in biotechnology, where breakthrough products further stimulate sensational spurts of growth. Experts believe that biotechnology will become the dominant U.S. growth industry of the 1990s with sales expected to reach $50 billion globally by the year 2000.

In recent years, medical firms--especially pharmaceuticals and for-profit hospital chains--were a haven for investors in search of long term growth, security, and a favorable rate of return. In fact, last year *Money Magazine* listed three health care corporations among the top eight powerhouse firms in the U.S. for investment potential. Today, however, because of the implications from national health care reform, many investment and industry analysts are beginning to hedge their unbridled endorsement of medical related firms as a long-term investment vehicle. Health care employment continues to grow at an annual rate of eight percent. This eight percent does not include health insurance, medical equipment and supply, and pharmaceutical companies. In fact, half of the new jobs created during the most recent recession came from the health care industry.

On the international scene, foreign health care companies are providing stiff competition to U.S. firms in pharmaceuticals and equipment. Nevertheless, the U.S. enjoys a favorable balance of trade from export of health care products and technology. U.S. businesses that supply the world's health care market are among the few remaining high technology industries still holding an impressive position in the global economy. As an example, U.S. drug companies account for 42 percent of worldwide pharmaceutical sales, and in 1991, exports exceeded imports by $1.3 billion.

Overall, the U.S. health care industry is strong and thriving. It still provides an acceptable--albeit somewhat less attractive and less predictable--long-term investment vehicle. Short term rates of return remain favorable, and top salaries are paid to health care executives, clinicians, and skilled technicians. Many health care forecasters predict that growth in the traditional health care industry will slow but that new opportunities and products will become available.

## TRENDS AND OUTLOOK

### Health Care Costs

Health care costs have escalated out of control and now pose a serious threat to our instruments of national power. In 1992, U.S. expenditures for health care reached $838.5 billion, exceeding 14% of GDP. This is far more than that of any developed nation. On a per capita basis, these expenditures exceeded $3,160 annually. More importantly, since 1980 the nation's expenditure for health care has increased over 400 percent. Annually, the nation spends three times more on the health care industry than it does for its defense and six times the total for U.S. farm output. In 1993 this nation's health care expenditures are expected to increase by $90 billion. Unless fundamental changes are made in this segment of our economy, health care expenditures are expected to exceed 20 percent of GDP by the year

2000 and 30 percent by 2010.

For all it spends on health care, the United States may not be getting its money's worth. For example, the U.S. ranks 20th in infant mortality out of 22 members of the Organization for Economic Cooperation and Development, and it ranks in the lower half for life expectancy.

### Economic Impact

For most businesses, health care is the second largest element of expense after salaries. Health costs place U.S. industry at a disadvantage compared with overseas competitors. Today, each vehicle General Motors produces reflects $1,000 in employee health care costs. In 1989 Ford spent $311 per vehicle made in the U.S. on employee health care costs, while Canadian automakers spent only $49.80. By 1991, Ford's cost had risen to $725 per vehicle, and its employee health care bill was 20 percent of total payroll costs. In comparison, Ford's overseas plants paid only one percent in the United Kingdom and four percent in Germany of their total payroll costs for employee-provided health care. In the U.S., health care is the fastest-growing segment of total employer costs, growing at a rate of 15 to 20 percent annually.

The high cost of health care has also contributed to the U.S. budget deficit. The Federal government is a major purchaser of health care under the Medicare and Medicaid programs. Federal spending for Medicaid, which began at as a modest $7.6 billion program in 1967 (1989 dollars), cost $68 billion in 1992, and is expected to reach $146 billion by 1998. Starting at $17.6 billion, Medicare grew to $129 billion in 1992 and is predicted to reach $259 billion by 1998.

### Cost Factors

Multiple factors have contributed to the rising cost of health care. The three most significant contributors to cost increases interact with and reinforce one another. They include an imbalance of specialty over primary care, growing reliance on expensive and sophisticated technology, and payment policies that incentivize growth of specialist care and subsidize technology as an end in itself.

Of the 600,000 U.S. physicians, there are three specialists for every doctor engaged in primary care. The reverse of this ratio is the case in the United Kingdom; the numbers of specialists and primary care physicians are roughly equal in Sweden and Germany. The U.S. medical education system, acknowledged to be the world leader in technical excellence, places high value on the achievements of specialist teams who apply sophisticated technology to the diagnosis and treatment of diseases that have reached a life-threatening stage. Students and trainees are given every intellectual and economic motivation to specialize; a career in primary care assures longer hours, lower income, and lower professional esteem.

Sophisticated testing and technology is the hallmark of specialty care. Specialists are trained and expected to rapidly achieve a definitive answer and optimal outcome for complex problems with the most advanced methods. On a per capita basis, such expensive tests as nuclear magnetic resonance imaging (MRI) and computerized axial tomography (CAT scans)

are far more heavily used in the U.S. than in Europe. Technology increases overall health care costs by expanding options for testing and treatment. The improvement in outcome in a given patient is often marginal compared with the added cost. Some critics contend that as much as 20 to 50 percent of the money spent for new technology may be wasted on procedures and devices that offer no major advantage in efficiency or efficacy.

Current payment policies preferentially reward specialist care and sophisticated tests on a fee-for-service insurance reimbursement basis. Payment scales ensure higher income for specialists who perform more procedures. There is no corresponding incentive for primary care physicians to avoid unnecessary specialist referrals, and patients are conditioned to demand specialist care. Specialists, in turn, must achieve high utilization of expensive equipment to cover its costs, and are held in the courts to a higher "standard of care," a standard that encourages using all testing at their disposal. Analysts have estimated that up to $200 billion may be spent annually on procedures that would be avoided if the same illnesses were handled by primary health providers, with little difference in outcome.

Litigation and defensive medicine also are cause for increased cost. While malpractice premiums cost physicians approximately $4.5 billion in 1990, the largest cost associated with malpractice comes from the practice of defensive medicine. According to the American Medical Association, defensive medicine annually adds $21 billion to the U.S. health care bill. A senior Rand Corporation analyst believes that $132 billion is needlessly wasted on unnecessary care and defensive medicine combined. The increased cost of malpractice insurance premiums has forced many physicians and hospitals to either raise fees or eliminate medical services. The trend toward increased litigation and the growing number and size of malpractice awards have led many states to cap amounts patients can be awarded for pain and suffering.

Substantial sums are also wasted each year administering the complex health insurance billing system. The General Accounting Office estimates that the United States could save up to $100 billion a year if it adopted a national health insurance plan like Canada's.

The aging U.S. population has also added to the nation's health care bill. As a group, elderly citizens are the largest consumers of health care in America, and also the fastest-growing demographic group. They have grown from seven percent of the American population in 1940 to 12.7 percent in 1990. By the year 2030, the Census Bureau projects that the elderly will comprise 25 percent of the population. A person over 75 years of age uses 10 times the medical care of a 40-year-old. The share of health care resources devoted to older patients will continue to increase.

The nation also spends a large percentage of its health care resources for care of seriously ill patients. This amount is expected to increase in the future as more Americans show signs of infection with the human immunodeficiency virus (HIV). Spread of HIV is already a major concern as many of those infected receive costly drug therapy, and patients in the advanced stages of the disease require expensive hospitalization or home health services.

According to the Health Care Financing Administration, Medicaid already pays $2

billion a year for AIDS cases, and costs for treating all HIV infected persons could reach $10.4 billion by 1994. This amount is projected to increase sharply as an estimated 1.5 million Americans with the HIV virus progress to AIDS over the next 10 to 15 years. With a projected lifetime cost of $94,000 per case, treatment of those already infected will cost $141 billion (1992 dollars). When costs for treating the additional 50,000 new cases annually are added, the figure becomes even more significant.

Continued rapid spread of HIV in the adolescent and young adult population will exact a much greater additional cost in terms of lost productivity and social instability. The number of teenagers with AIDS increased by more than 70 percent in the last two years, and AIDS has become the second leading cause of death for men between the ages of 25 and 44.

**Uninsured and Underinsured Americans**

In addition to its effect on the nation's economy, the rising cost of health care has also affected the wealth and purchasing power of individual citizens. The average family now pays $1 out of every $7.50 for health care--a 33 percent increase since 1980, while real income has remained virtually unchanged. As a result, a growing number of Americans can no longer afford, or have elected to no longer pay, for the cost of health insurance. Approximately, 37 million Americans, including 11 million children, are estimated to have no health insurance. An additional 50 million citizens are inadequately insured.

The ranks of the uninsured include more than just the poor and the unemployed. They also include many full-time workers whose pay has failed to keep pace with the rising cost of health insurance, or whose employers cannot afford to offer health benefits. Also counted in this group are many who are denied coverage because of an existing illness or disabling condition.

**Cost Containment Initiatives**

Over the years, a number of initiatives to contain costs have been considered by the Federal government and some have been implemented. Their success has been mostly disappointing. State governments and industry have also become involved and have experimented with their own cost containment programs. Some of these have received wide attention. For example, the state of Oregon recently received permission from the Department of Health and Human Services to deny some high cost, low benefit treatments to provide more comprehensive primary care.

**Physician Payments**

In an effort to contain physician costs, Congress recently mandated implementation of a new schedule of fixed fees for treatment of Medicare patients. The new fees, referred to as Resource Based Relative Value Scales (RBRVS), consider the work physicians perform and the cost of their training and practices. Also included are such factors as the time spent on procedures and the effort, judgment, and stress involved. Because the new scales reward diagnostic and primary care skills more than technical skills, officials predict that they will encourage lower-technology, and therefore lower-cost treatment.

## Hospital Payments

Beginning in 1983, the traditional reimbursement system for hospital care of Medicare patients was replaced by a Prospective Payment System (PPS). Under PPS, specific illnesses are lumped into Diagnosis Related Groups (DRGs) which form the basis for hospital reimbursement. DRGs have helped slow the real growth in hospital expenditures, but they have also given hospitals incentives to discharge patients more rapidly to reduce losses or improve profits. The new policy has shifted the costs from hospitals to outpatient settings. In the two years following implementation of DRGs, physician office laboratory fees increased by 182 percent, and outpatient hospital bills by 68 percent. At the same time, the number of Medicare enrolles increased by only four percent.

Industry trends suggest that hospitals have been suffering from the current reimbursement system. According to the Department of Commerce, nearly nine out of ten hospitals may be operating without a profit. Moreover, profit margins of all for-profit hospitals declined during the first four years of the Prospective Payment System. Many hospitals are responding by simply closing their doors or, in the case of large public hospitals, by watching their infrastructure decay as they are denied realistic rates which would allow for capital improvements.

## Other Trends Affecting Payments

Frustrated by the increasing share of revenue being paid for employee health benefits, many leaders in private industry have initiated their own programs to contain costs. One approach used by many companies to limit health care costs is to enroll employees in Health Maintenance Organizations (HMOs). HMOs have existed in limited numbers since 1929, but have recently increased in popularity. They attempt to control costs by negotiating annual per capita rates with hospitals and/or physicians. In the early 1980s, HMOs recorded several successes for their subscribers: inpatient hospital days were approximately half that of the national average, the average length of hospital stay was 25 percent shorter, and costs were 15 to 25 percent lower than those under the traditional system. However, HMOs also have some drawbacks. They are privately administered, available to only a relatively small portion of the population, with approximately 31 million enrolled, and restrict patients' choice of physicians. Moreover, HMOs have been accused of excluding patients with pre-existing medical conditions, leaving them to be absorbed by the traditional sector. The initial success of HMOs is attributed to enrolling a healthier pool of patients than those covered under traditional health insurance plans and to using utilization review and pre-admission certification. In recent years, HMOs have experienced similar cost increases as those under traditional health care plans.

Managed care is another initiative which is being used more frequently to control hospital and physician costs. Under managed care, primary care physicians serve as "gatekeepers" to reduce unnecessary services and specialty referrals. In some instances, managed care has been shown to reduce hospital costs by 25 to 40 percent when compared with the traditional system of fee-for-service reimbursement. The Department of Defense has introduced several model systems of managed care in its hospitals on a test basis in recent years.

Several states have developed innovative programs to limit health care spending. Oregon has begun to experiment with non-price rationing. In Oregon, an 11-member commission prioritized a list of medical services for Medicaid beneficiaries. Services are ranked on the basis of the most favorable ratio of cost-to-benefit of treatment. The size of Oregon's Medicaid budget determines which services on the list will be funded. The goal is to make rational decisions on what services and benefits are going to be provided and to do the most good for the most people within a limited amount of funds.

### Impact of Defense Reductions

Reductions in the defense budget will have negligible impact on the health care industrial base. DoD is a relatively small customer for health care supply and equipment manufacturers and distributors.

Changes in health care funding and policy, on the other hand, may have a major impact on combat readiness of service members and health of the DoD beneficiary population. Imposition of regulations and norms designed for civilian health care on a military system should consider geographic dispersion, health problems of training, field deployment, actual combat, retention, and the dependence of mission success in combat on the confidence that dependents are having their health needs met by a supportive system.

### New Directions

The present administration has made health care reform a centerpiece of its political effort. As of this writing in May 1993, a detailed program has not yet been proposed, but it could contain: caps on physician, hospital, and drug costs, managed competition among HMOs and similar entities for health care insurance dollars on a capitation basis, service by the government as the default guarantor of insurance for those who cannot afford it, and increased revenue generation to fund coverage of the currently uninsured population. The success of this reform effort appears to be central to the long-term economic well-being and competitiveness of the United States.

## NATIONAL SECURITY RESPONSE CAPABILITY

### Disaster Response

The Federal Emergency Management Agency (FEMA) has developed a comprehensive Federal Response Plan which provides the basis for mobilizing and coordinating the response of all appropriate Federal agencies during national emergencies. Included in the plan under Emergency Support Functions (ESF)#8 are provisions for health and medical support. The Department of Health and Human Services (DHHS) has been designated as the lead agency responsible for health and medical responses while the Department of Defense (DoD) has been tasked to provide a support role. Recent experience in dealing with disasters such as Hurricane Andrew has shown that only DoD possesses the necessary resources and capabilities to respond quickly and manage large scale casualties. Such large disasters quickly out-strip the capability of local and state agencies. This mandates that representatives from DoD be involved from the onset of large scale disasters to

assess the level of assistance required. Recent experience has also taught us that all involved agencies must develop better methods of information sharing, particularly information pertaining to individual agency capabilities.

## National Disaster Medical System

The National Disaster Medical System (NDMS) is a cooperative effort of DHHS, DOD, DVA and FEMA with state and local governments and the private sector. The NDMS provides a coordinated system of medical assistance, casualty evacuation, patient receiving, and acute care in response to a national emergency. Under this system over 1,700 civilian hospitals have committed over 100,000 beds to this purpose. Disaster Medical Assistance Teams (DMATs) are the primary resource within the NDMS for providing on-site emergency services, transfer points, and reception sites. If additional assets are required on location, three DMATs may be combined to form a Clearing Staging Unit (CSU). Our current Federal Response Plan calls for the establishment of 150 such teams.

Management responsibilities for the NDMS rest within the Office of Emergency Preparedness (OEP), Department of Health and Human Services. When a national disaster occurs the Assistant Secretary for Health, DHHS has responsibility for activation and the control of the NDMS. In a military contingency, the Assistant Secretary of Defense (Health Affairs) may also request its activation. While all assets of the NDMS are available to support military contingencies, medical assistance teams and units can only perform casualty management support within the United States. Although many teams have been organized, few have received appropriate training in disaster response. We must devote additional attention and resources to the training of these teams in the future.

Overall, the American health care system appears capable of meeting our nation's needs both during war and national disasters. There appears to be an adequate supply of hospital beds and medical staff. Our ability to surge the production of medical supplies, as demonstrated in Operation DESERT SHIELD/STORM, appears to be adequate for our medical industry as it currently exists.

## Humanitarian Assistance

Humanitarian Assistance is not new to the United States military. The U.S. has continuously provided this type assistance over the years. The difference today is the magnitude of the world events which require this form of assistance. The recent past has seen an unprecedented number of situations in which the U.S. armed forces have been involved in humanitarian missions. Examples include:

- Operation SHARP EDGE, evacuating U.S. and other diplomats and civilians from Liberia in the face of civil war;

- Operation EASTERN EXIT, rescuing U.S., allied, and friendly citizens from dangers of civil war in Somalia;

- Operation PROVIDE COMFORT, safeguarding and providing food and shelter for Kurds in northern Iraq;

- Operation SEA ANGEL, providing relief to Bangladesh after a typhoon;

- Operation FIERY VIGIL, providing medical and evacuation support to the Philippines during eruption of Mount Pinatubo;

- Operation GTMO, providing temporary shelter and care at the U.S. Naval Station at Guantanamo Bay, Cuba, for the Haitians rescued at sea;

- Operation PROVIDE HOPE, transporting food and medical supplies to Commonwealth of Independent States;

- Operation RESTORE/CONTINUE HOPE, providing food and medical supplies, and restoring order to Somalia;

- JTF Andrew, providing food and medical supplies, emergency services, and shelter to south Florida after Hurricane Andrew; and

- Operation PROVIDE PROMISE, providing medical supplies and equipment, food and shelter to the former Yugoslavian states.

Increasingly, it has been recognized that the organizational and logistical capabilities (especially medical) of the armed forces are uniquely able to provide humanitarian assistance to countries, including our own, suffering natural and man-made disasters. The employment of the U.S. armed forces for humanitarian missions is likely to be even more common in the future. Unfortunately, humanitarian assistance missions can markedly degrade DoD's warfighting medical response capabilities.

**Wartime Surge/Mobilization Potential**

The Department of Defense medical mission first is to maintain combat medical readiness of the armed forces and to support them during military operations; and second, to provide peacetime medical services and support to members of the armed forces, their dependents, and others entitled to DoD medical care. The health care providers, medical equipment, and medical supplies required for surge/mobilization are, in many instances, the same as those used daily for the provision of our nation's health care needs.

Assets are maintained in both the active and reserve forces: Army ratio--30 percent active versus 70 percent reserve; Navy ratio--53 percent active versus 47 percent reserve; and Air Force ratio--89 percent active versus 11 percent reserve. With the drawdown of the military and decreasing defense budget, the medical force structure and active/reserve mix is a major issue, both for the Department of Defense and the Congress.

***Personnel.*** In the past the military medical system has suffered from an overall shortage of clinicians in key physician and nurse specialties to meet wartime requirements. DESERT STORM proved that the nation's health care system could provide the necessary specialists

during mobilization. However, most individuals required training in basic, go-to-war, survival skills, and military orientation and use of equipment prior to deployment to combat. As the downsizing continues, the availability of a trained responsive medical force will increasingly be in question.

***Supplies and Equipment.*** The military medical mission requires few special items of supplies and equipment that are militarily unique. This factor allows the civil sector to be the leading edge in technology. As items are approved for the market, the military becomes merely another buyer. The representatives of the medical industry continue to maintain that they would have no problem reacting to DoD surge requirements during mobilization and national emergency. DoD has initiated programs that emphasized "jointness" in the medical arena. The Army has been designated the overseer of Joint Medical Logistics, Class VIII. The tri-service Deployable Medical System (DEPMEDS) has resulted in standardized field hospital system for all services. However, fewer 500 and 1,000 bed field hospitals are required in the post-cold era. The services are all turning to smaller, more easily deployed units.

***Pharmaceutical.*** The pharmaceutical portion of the medical industry is healthy. The DoD peacetime requirements make up less than five percent of the total market. The major pharmaceutical companies were able to respond to military requests during Operation DESERT STORM and on-going humanitarian relief operations. This was accomplished through use of stock-on-hand and minor surges in production. At the same time, the civilian market was unaffected. The view is that the pharmaceutical industry would have little difficulty in supporting DoD during a mobilization or major contingency operation. However, exceptions do exist for immune serum globulin and autoinjectors to protect against chemical agents. The answer to this problem is to support a commercial capability to manufacture, stockpile, and maintain the autoinjectors.

***Vaccines.*** The Department of the Army has the responsibility for monitoring the biological warfare threat and developing and procuring appropriate vaccines. Biological vaccines of this nature have little or no civilian application, which discourages commercial research and production. The FDA holds tight rein on production processes and control use. Many vaccines, for this reason, remain in the investigational stage of production. This is one area that the government must provide financial support to ensure that technology and manufacturing facilities are available in the event of mobilization and a major contingency.

***Hospital Bed Capacity.*** The U.S. health care industry has 30 percent excess inpatient bed capacity, running an occupancy rate of approximately 65 percent. During mobilization and major contingency the DoD facilities currently have the capability to support the build-up phase. The Department of Veterans Affairs (DVA) and the National Disaster Medical System (NDMS) provide the necessary surge capability stateside. Public law mandates that DVA provide the primary contingency back-up flow for DoD for the sick and wounded personnel of the military. The DVA goal is to provide 25 percent of its staffed operating acute beds within 72 hours of activation. The NDMS estimates that 100,000 acute care hospital beds will be made available for surge response in the event of national emergency. The overriding concern of the planning agencies is a simultaneous wartime mobilization and a major natural disaster within the United States.

## TRENDS AND OPPORTUNITIES IN SCIENCE, TECHNOLOGY, AND MANUFACTURING

### General Trends

Several industry-wide trends are worth noting:

The implementation of Total Quality Management (TQM) principles was evident in most of the U.S. manufacturing facilities visited. Senior management seemed to be committed to the TQM philosophy and sees producing timely, quality products as the key to successful competition. Employees were responding with new ways of doing things better. This admittedly cursory review could not determine the true level of success, but it is obvious that TQM has been embraced by most of the U.S. health care industry. In Europe, the focus on quality was also very high. While quality as a management philosophy was not widely attributed to TQM, many of its basic principles were in evidence.

An increasing use of automation was another trend observed in plants manufacturing health care products. Most of the automated machinery producing pharmaceuticals was produced in western Europe or Japan and, interestingly, identical machinery and processes were seen in use to produce different drugs in the U.S., Sweden, and Germany. Automation and improved process control are increasingly being used in manufacturing high-technology medical equipment and supplies. Even in the traditionally labor-intensive medical instrument industry, efforts to automate finishings are underway. There is a growing trend toward globalization of firms involved in health care manufacturing and research and development. This growing internationalization tends to blur the national identity of products. In fact, the health care industry cares little about national origin of products; users are interested in price, efficacy, and service.

A final industry-wide trend is growing reliance on just-in-time (JIT) inventory programs. This is a strategy for cost control which emphasizes delivery of supplies when they are needed--just-in-time. Hospitals are able to reduce or eliminate large inventories of costly items and free up storage space for other uses. Manufacturers and distribution organizations are developing dynamic JIT relationships with sub-tier suppliers. While cost efficient, this study group was concerned that JIT systems might limit surge capacity during a national emergency, especially if second tier suppliers are located off-shore. However, industry management did not seem to share this concern. The JIT philosophy is beginning to make important headway with defense medical facilities. For example, a program called Prime Vendor has been instituted at the National Naval Medical Center at Bethesda, Maryland in which pharmaceutical suppliers provide two to three day service on most items and still save military hospitals 15 percent of the normal 22 percent defense supply system's surcharge. DoD is considering other proposals, such as having vendors maintain a surge inventory for a relatively low "inefficiency charge."

Additional trends, opportunities, and concerns that affect specific segments of the health care industry are discussed below.

**Pharmaceuticals**

According to the Department of Commerce, the United States remains the world center for the research and development of new pharmaceuticals. The U.S. is also the largest single market for pharmaceuticals, accounting for almost 67 percent of world sales. U.S. drug industry sales increased by 2.5 percent in constant dollars in 1992 to approximately $64 billion. U.S. exports, totalling $6.8 billion in 1992, exceeded imports by over $1.3 billion.

A key concern in the drug industry is the increasing difficulty and delay in developing new pharmaceuticals. Industry sources pointed out that it takes 10 to 15 years to bring a new drug to market. This includes an average of 30 months to obtain FDA approval--despite the FDA's stated goal to complete the approval process for emergency drugs in 6 months and for regular drugs in 12 months. Industry sources partly attribute this long lead time to governmental and consumer demands for zero risk.

Closely related to long development times is the increasing cost of research and development. The pharmaceutical industry invests from 12 to 20 percent of gross income in research and development, one of the highest rates of all American industries. This is a high-risk, high-reward industry, but with higher than average profit margins. Bringing a new drug to market is estimated to cost well in excess of $200 million, not counting the marketing costs which may be several times higher. Most firms concentrate research into a few areas in which they feel they have special expertise. However, long development times and high cost can discourage research into new products which lack a broad market or which are too risky. Both nationally and internationally, the pharmaceutical industry increasingly manages these high development costs by forming alliances with universities and the government whenever possible. Mergers, partnerships, and joint ventures have also become more common, (e.g., AIDs research).

Almost 47 percent of U.S. pharmaceutical exports are to the European Community. The Japanese market accounts for 16.5 percent and Canada/Mexico 13.3 percent. Harmonization of pricing and reimbursement constraints are particular concerns for the U.S. industry which has come under attack for its perceived high prices. Regulatory practices in some foreign countries may encourage similar restrictions in the U.S. This is particularly true as it relates to price controls common in western Europe, and Japan's requirement for mandatory price reductions at various intervals in a product's life.

A potential problem that is particularly evident in the drug industry is the growing dependence on international sources for basic supplies and equipment. A visit to one major pharmaceutical manufacturer revealed that many of their basic compounds come from Japan; while almost all production machinery is manufactured abroad. While this does not appear to be a problem in today's international environment, second tier suppliers of critical materials and machinery should not be overlooked in the evaluation of U.S. wartime mobilization.

Finally, it is interesting to note that cost benefit analysis has become an important consideration in the development of new drugs. One major manufacturer stated that they are increasingly interested in developing only "blockbuster" drugs with high sales potential; firms are now more concerned about assessing the incremental benefits of new products (profits) before entering development.

## Medical and Dental Devices and Technology

The United States produced 48 percent of the $70.9 billion global market of health care technology products in 1991. The U.S. consumed some $31 billion, 46 percent, of the market. The purchase of technology consumes about five percent of total U.S. health care dollars. However, the increasing reliance on advanced technology has been blamed for 20 to 50 percent of the increase in total U.S. health care expenditures. In view of these figures, industry representatives were quick to point out that advanced technology also reduces total costs by providing less expensive and safer, less invasive alternatives to conventional diagnostic and treatment methods.

The Department of Commerce has reported that medical equipment manufacturers experienced another good year in 1992. Sales increased by 11.5 percent and are expected to increase by another 8.5 percent in 1993. In addition, exports increased by almost 9.5 percent in 1992 to a total of $7.4 billion. U.S. exports exceeded imports by some $3 billion, with imports holding a fairly steady 14 percent of the U.S. market. The Health Industry Manufacturer's Association (HIMA) reports that the United States is the leading exporter of medical technology and dominates the market in some areas. The U.S. medical products industrial base is also sound in the areas of supplies, instruments, and imaging. Although manufacturers were generally pleased with their strong performance, they also expressed several concerns for the future. Because of its size and accessibility, the U.S. market is aggressively targeted by foreign firms.

Research and development in this sector remains high at 6.3 percent of sales compared to an average of 3.6 percent for all American industries. The industry's continued strong performance can be attributed to its competitive level of investment in research and development; the European Community averaged five percent while Japan spent six percent in 1991.

Technological advances have allowed for the development of smaller, more sophisticated, compact, and flexible devices and equipment. The trend towards reduction in size and weight has also been extended to sophisticated diagnostic and imaging equipment such as computerized tomography (CT) and magnetic resonance imaging (MRI). These high cost devices have continued to proliferate and have become completely integrated into the practice of medicine in the U.S.

The DoD medical system will also benefit from the trend towards smaller, lighter and more mobile equipment. Diagnostic machines that were previously limited to fixed facilities are being designed as portable systems for transport to remote locations and combat theaters. Increased availability of diagnostic equipment in combat zones could decrease the number of patients who have to be evacuated and promote more rapid return to duty of ambulatory patients.

A concern of medical instrument manufacturers is the growing competition from low quality forgings supplied by some foreign manufacturers. They emphasized that quality forgings provide the "best value" because of their superior performance and durability. However, quality forgings are only available from a few sources. One manufacturer indicated that three suppliers provide 70 to 80 percent of the forgings used in the U.S., and two of these

are located overseas. The single domestic source is comparatively small, but growing.

Like the pharmaceutical industry, supply and equipment manufacturers are experiencing increased pressure from new legislation and aggressive enforcement by the Food and Drug Administration. Recently enacted regulatory requirements, such as the Safe Medical Devices Act of 1990, add to development times and costs. Prior to marketing, manufacturers are now required to prove that new devices are safe and effective. In addition, they are now required to monitor and report problems that occur with certain categories of equipment after marketing. The tradeoffs between risk and developmental costs that are becoming increasingly more common are likely to leave both the industry and the public dissatisfied. In 1992, over 4,300 new medical devices received Federal Drug Administration (FDA) pre-market approval, down almost 10 percent from 1990. Approval time averaged 633 days for these devices.

**Digital Technology**

Digital technology is gradually being integrated into the diagnostic imaging services of foreign and U.S. hospitals. The new Madigan Army Medical Center at Fort Lewis, Washington, is perhaps the most complete advanced installation of digital technology in the world. Application of this technology offers many opportunities for health care providers, managers, and patients. The application of digital technology to imaging systems can eliminate the requirement for separate libraries to hold patient radiographs and diagnostic surveys. This will conserve hospital space and staffing requirements. Digital technology also offers the opportunity for more rapid and flexible image retrieval, thereby increasing efficiency and saving time. An additional benefit, and one that is of particular interest to the Department of Defense and rural hospitals, is the potential for immediate worldwide transmission of patient images. Potentially, digital technology can also be applied to other hospital diagnostic and patient monitoring systems.

Although digital technology shows great promise for reducing costs and increasing efficiency, it cannot realize its full potential without the cooperation of major medical equipment manufacturing companies. They must agree to develop standards for open systems architecture to allow for integration of different diagnostic imaging and monitoring systems into a single network.

**Biotechnology**

Biotechnology is a relatively new and emerging industry that has already revolutionized the understanding, diagnosis, and treatment of a wide variety of diseases. Products and procedures such as monoclonal antibodies, DNA probes, and recombinant DNA technology, allow for the manufacturing of therapeutic and diagnostic materials in larger quantities and with greater specificity than ever before. In particular, gene therapy shows great promise in the treatment of a wide variety of hereditary and malignant diseases. The U.S. government's Human Genome Project was launched in 1990, at an estimated cost of $3 billion, to map and characterize the approximately 100,000 genes that each human carries. This 15-year effort will provide a tremendous body of knowledge on disease pre-disposing genes that can be used by industry to develop commercial treatment applications.

The U.S. is the world leader in research and commercialization of biotechnology products, but the industry is still in its infancy. The U.S. will face strong international challenges in the future, primarily from Europe and Japan. As with pharmaceuticals and high-technology medical equipment, competitiveness is significantly affected by access to capital for research and development, protection of intellectual property rights, and government regulation.

The 1980s was a period of rapid growth and expansion for U.S. biotechnology companies. Recently, however, there has been a trend towards consolidation. Many companies have merged, been acquired, or formed partnerships or alliances to offset the high cost of research and development, to obtain additional funding, and to gain access to distribution networks. Although most of these collaborative efforts have occurred among U.S. companies, the number of alliances with foreign firms has also been increasing. Recognizing the importance of biotechnology to the future economic strength of our country, the President's Office of Science and Technology has designated biotechnology as a national critical technology. As impressive as this title may be, it offers no long-term protection against foreign competitors. To maintain its edge in the biotechnology industry, U.S. companies will need to continue to invest heavily in research and development. Moreover, they will need to translate their success in the laboratory into effective and affordable commercial products.

## INTERNATIONAL TRADE AND COMPETITION

The current world economic climate does not appear favorable for investment abroad. Economic recession in Europe and Japan continues unabated. The former Soviet Union and Warsaw Pact countries are laboring under high inflation and foreign debt as they attempt conversion to market-based economies, simultaneously hampered by political unrest and ethnic and religious intolerance.

Even if the foreign investment arena looked much more promising, few U.S. health care industries are well positioned to take advantage of potentially lucrative markets. Investment capital is not in great supply (caused mostly by the government consuming the available capital to pay the interest on our four trillion dollar debt), and what is available costs more because the demand exceeds supply. Recent record profits in the industry appear to be short term in nature, generated primarily by medical technological innovation, and major corporate restructurings. For the most part, restructurings are one-time savings and research and development innovation will not produce the same profit margins in the future if the Clinton Administration follows through on its plan to discourage companies from developing medical technologies whose costs outweigh the benefits. Slow economic growth at home, uncertainty over the direction of the Clinton Administration's economic program, and lack of progress on the North American Free Trade Agreement and the Uraquay round of the GATT negotiations portend risk-averse U.S. business strategies for the foreseeable future.

Although corporate restructuring and a commitment to total quality management have made the U.S. health care industry "lean and mean," it continues to face access restrictions to the Japanese market and subtle restrictions in the European Community pertaining to licensing, certification and safety. The U.S. share of the international health care market will not improve without successful resolution of the GATT negotiations.

## CONCLUSIONS AND RECOMMENDATIONS

### Health Care Costs and Reform

If health care spending is not slowed, Americans will face the almost certain prospect of lower wages as businesses pass on the rising cost of health insurance, higher taxes as the Medicaid and Medicare costs double in the next six years,and higher trade deficits as health care costs are added to the costs of good and services.

**Recommendations:**

- Establish a formal approval process for evaluating the cost effectiveness of new technologies and procedures, allowing reimbursement for only those specifically approved.
- Restructure the health care insurance industry and reduce unnecessary administrative costs.
- Provide universal health coverage to all Americans, including those with pre-existing conditions through either a compulsory contributory health insurance plan and/or national health care coverage.
- Increase the ratio of primary care physicians to specialty physicians. Currently, one to three, the ratio more appropriately should be three to one to provide increased emphasis on family practice, general internal medicine, and general pediatrics. Make a career in primary care as professionally rewarding as specialty practice. Restrict specialty care, with its extensive testing and costs, to necessary referrals of patients by primary care providers.
- Establish nationally acceptable standards of care protocols and treatment guidelines.
- Reform the malpractice tort award process.
- Encourage less physician and hospital-based care but encourage more individual responsibility for wellness and healthy lifestyles.
- Challenge the American public to accept--from a national/community perspective-- that upper bounds must be placed on its ever increasing quest for more medicine, even when that medicine is of little or no marginal value.

### National Security Response Capability

The U.S. has a well developed health care infrastructure that can provide adequate resources for responses to most national emergencies. Trained health care providers, patient evacuation assets, and acute care hospital beds available through the Department of Veteran Affairs and the National Disaster Medical System provide sufficient surge capability to augment DoD medical resources. With few exceptions, medical supply and equipment

manufacturers and distributors can also surge to meet almost any disaster or military contingency. However, DoD will need to develop a strategy to ensure adequate supplies of chemical and biological defense agents which are not readily available from commercial suppliers.

**Recommendations:**

- Provide funding to maintain a warm industrial base for chemical biological defense agents to ensure a surge capability.

- Develop incentives for pharmaceutical companies to produce critical vaccines for national security requirements.

- Increase funding for use of military medical units in humanitarian assistance operations.

- Supplement the DoD medical supply distribution system with commercial distributors to increase efficiency and improve surge capability.

- Assess the feasibility of forming a DoD joint medical command or forming a Defense Health Agency under the Assistant Secretary of Defense (Health Affairs) to centralize and better coordinate peacetime medical activities and prepare for military operations.

- Improve information sharing among agencies involved in responding to national disasters.

- Provide realistic training opportunities for emergency response teams under FEMA guidance.

**Health Care Industry**

In general, the U.S. health care industry is strong, but profits have slowed because of the uncertainties surrounding health care reform. Companies that provide services, distribute supplies, or manufacture equipment and technology for the world health care market are among the most internationally competitive of all U.S. businesses. Moreover, they are in a favorable position to maintain their leadership position in the world economy by emphasizing quality management principles and by continuing to invest heavily in research and development. However, threats exist domestically and abroad in the form of increased regulation, price controls, piracy of product and process patents, and restrictive markets.

**Recommendations:**

- Increase coordination between U.S. and foreign agencies responsible for medical device and pharmaceutical regulations to improve opportunities in international markets.

- Continue aggressive U.S. participation in GATT negotiations to ensure free, fair, and

open trade practices and to ensure protection for patents, copyrights, and intellectual property rights.

- Support efforts by the Health Industry Manufacturers Association (HIMA) and National Electronic Manufacturers Association (NEMA) to harmonize regulations governing medical devices.

- Continue to push NAFTA negotiations to establish a strong regional free trade market for U.S. produced goods and services.

**Trends and Opportunities in Science, Technology, and Manufacturing**

This portion of the U.S. health care industry is incredibly robust and competitive. In fact, in general it can be said that U.S. is the world leader. However, the globalization of the health care industry is increasingly blurring the distinctions between foreign and U.S. firms. The health of this portion of the industry necessitates few governmental initiatives to improve competitiveness. Due to the size of the home market, top educational institutions, competitive percentage of sales plowed back in to research and development, strong management and a motivated workforce, the U.S. can respond to foreseeable mobilization requirements involving drugs, supplies, and equipment.

**Recommendations:**

- Accelerate and improve the FDA's review and approval of new drugs and medical technology.

- The U.S. military should continue to incorporate digital technology systems into its hospitals to demonstrate its efficacy and cost effectiveness.

- Because profits on drugs are higher in the U.S. than in many other developed countries, the Clinton Administration's health care reform initiative should include some mechanisms for voluntary or mandatory price controls.

- Facilitate the research and commercialization of biotechnology products by limiting unnecessary government regulation and speeding the approval of new products.

# DEFENSE INDUSTRY STUDY

# # 14

# EDUCATION

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### Domestic

| | |
|---|---|
| Fairfax County Public Schools | Fairfax, VA |
| Thomas Jefferson High School | Alexandria, VA |
| Xerox Corporation | Leesburg, VA |
| Northern Virginia Community College | Sterling, VA |
| U.S. Department of Labor | Washington, DC |
| U.S. Department of Education | Washington, DC |
| U.S. Senate | Washington, DC |
| National Education Association | Washington, DC |
| AFL/CIO Headquarters | Washington, DC |
| World Bank | Washington, DC |
| Organization of American States | Washington, DC |
| U.S. Agency for International Development | Arlington, VA |
| Community Renewal Society | Chicago, IL |
| Corporate/Community Schools of America | Chicago, IL |
| Archdiocese of Chicago Schools | Chicago, IL |
| Illinois Math and Science Academy | Aurora, IL |
| Motorola University | Schaumberg, IL |
| Chelsea School Project | Chelsea, MA |
| City Year Program | Chelsea, MA |
| U.S. Department of Labor, Regional Office | Boston, MA |
| Boston Private Industry Council | Boston, MA |
| John Hancock | Boston, MA |
| Raytheon | N. Andover, MA |
| Micro Society School | Lowell, MA |
| Maryland Department of Education | Baltimore, MD |

### International

| | |
|---|---|
| Department of Education and Science | London, UK |
| Department of Employment | London, UK |
| Enfield Country School | Enfield, UK |
| Queens School | Waterford, UK |
| U.S. Embassy | Berlin, GE |
| Ford Factory | Berlin, GE |
| Federal Institute for Vocational Training | Berlin, GE |
| Office of Senator for Education | Berlin, GE |
| Chamber of Commerce | Berlin, GE |
| Daimler-Benz Factory | Berlin, GE |
| Geweblichen Vocational School | Ohringen, GE |
| Zahnradwerke Transmission Factory | Neuenstein, GE |
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## INTRODUCTION

In 1983 the National Commission on Excellence in Education publicized the major deficiencies in the American educational system in its report A Nation at Risk. During the succeeding decade, primary and secondary education throughout the United States has been intensely analyzed. A Nation at Risk spawned what some refer to as the "Excellence Movement of the '80s." Bold experiments were launched across the nation. Small pockets of excellence emerged and were trumpeted as indications that the nation had turned the corner on education reform. However, national studies of American student performance continue to show that American children typically spend less time in school, expend less effort on studies, and learn less than other children in the rest of the industrialized world.

*The American educational system is not adequately educating our children to perform capably in the future.* The future work place will be characterized by global economic competition and interdependence and will demand high levels of technical competency and skills. Our students are leaving school unprepared for the challenges of the work place, and many corporations have been forced to embark upon substantial training programs to upgrade the basic skills and literacy of their workers to compete successfully against foreign businesses.

Future U.S. economic growth and prosperity depends on a highly skilled and literate American work force. Remaining competitive in the global marketplace requires that American businesses keep pace with the productivity, efficiency, and quality improvements demonstrated by European and Asian nations. Of perhaps greater significance, future American power and global influence will be based less on military might than on economic strength and vitality. *The need for an educated populace to assure future American economic vitality makes our educational system a pillar of our national security.*

Reform efforts have been undertaken in piecemeal fashion. Fragmented and isolated attempts at reform have achieved mixed results. No comprehensive overhaul of our educational institutions has been attempted, nor is there one staged for a dramatic unveiling. The "system" itself remains unresponsive to our changing society.

## STUDY GOALS AND PLAN

This industry study's general goal was to provide an executive level perspective of the U.S. education industry with respect to its capability to produce a qualitatively superior work force for the 21st century. In pursuit of this goal we analyzed: work force requirements necessary for maintaining a world class economy and a viable defense industrial base; specific characteristics of the education industry; U.S. education and training systems compared to those of other industrialized countries; and government policy options for national education reform that could improve economic competitiveness and defense industry production efficiency.

We examined all aspects of the manner in which America educates its people: pre-

school through college; public and private sector; local, state and federal. We compared practices in America's schools to systems found in other nations. Our focus in symposia speakers, field trips, and travel, however, has been on kindergarten through twelve (K-12) public schools, including the school-to-work transition. Most of us concluded that the crisis in K-12 education is indeed severe, and searched for the package of reforms that could remedy the system's ills.

Our report will review the results of our analysis. It will begin by reviewing the structure and operating characteristics of our educational institutions. Specific performance data and information outlining just where the system is falling short will follow. Reform options addressing these inadequacies will form the conclusion of the study. Many successful educational reforms, however, have already been enacted, and Appendix I discusses in detail the most significant of these efforts.

## SYSTEM STRUCTURE AND CONDUCT

### Governance

In the United States education is primarily a state responsibility. Local control of schools is a deeply imbedded principle in American culture. Consequently, nationwide "systemic reform" is difficult due to fiercely independent states and school districts -- especially since the federal government only provides 6% of the funds used to operate schools. Critical reforms such as standards, teacher quality, and school financing are not administered by the U.S. Department of Education. Moreover, school policies vary radically among states, among school districts, and among schools within districts. The result is a fragmented, decentralized system plagued by bureaucratic imperialism, whether the bureaucracy is a state Department of Education, a district school board, or a local teacher's union.

A close look at the school boards in our 15,350 school districts is illustrative. In theory, school boards are charged with representative governance of their school systems, and they have long been viewed by the public as an indispensable educational institution. However, their role in improving student performance has become ill-defined. Since 1950 school boards have lost influence "at the top, to federal and state legislatures, courts and interstate policy networks; at the bottom, to teachers unions and parents and special interest groups" (Chion-Kenney, 1993, p. E5). To maintain local political power boards have tended to micromanage administrative details rather than focus on educational reform. In the words of Michael W. Hirst, co-author of "Governing Public Schools: New Times, New Requirements", school boards are "a collection of individual agendas rather than a collective vision for school improvement" (cited by Chion-Kenney, 1993, pE5).

### Education System Characteristics

The structure and methods used in our schools resemble elements of factory design and organization -- a legacy of the Taylor model of scientific managements popular in mid-century. American students are educated in large, factory-like buildings. They are grouped

by age and ability. Instruction is organized in an assembly line fashion: students move from teacher to teacher, receiving instruction in short, 40-45 minute blocks of unrelated subject matter. Students focus on the same subject at the same time and move on to the next topic at the same rate. Great emphasis is placed on completing administrative procedures and learning basic facts, figures, and rules, but higher skills such as problem-solving, teamwork, and communication are neglected. Instruction frequently has little relevance to real world experiences, and school fares poorly against the varied attractions of modern society in the competition to maintain student interest and attention. In the end, students do not view the material as "valued knowledge" for understanding or long-term retention.

The Taylor model applies to teachers: they are required to use a curriculum pre-established and force fed with minor deviations from approved texts. School boards, state legislatures, school administrators, and unions all have a role in dictating what teachers should teach, how they should teach, what books will be used, when they will teach, and what administrative duties are necessary. Performance incentives, common in most professions, are often unavailable to teachers. Thus, the prime elements of a true profession are lacking, and the core of education -- the student/teacher interface -- suffers.

Despite its numerous flaws, the Taylor model proved to be an efficient and effective means of mass instruction through the mid-1960s. The increasing heterogeneity of America's student population, however, combined with the changing demands of the evolving work place have rendered Taylorism an increasingly irrelevant educational method.

Many U.S. schools have abandoned Taylorism and have implemented innovative teaching and curriculum management programs, which are responsive to their local community needs. But the relative quality of America's schools covers a broad spectrum. There are many good institutions that cannot be lumped into the general, and unfavorable, description of American schools provided above. To reinforce the central thesis of this paper: **There are still too many American schools turning out young men and women who are incapable of being gainfully employed in our economy, and even worse, who become burdens to a productive society.**

**Basic Skills for Work Place 2000 Characteristics**

The American education system has not adequately prepared the nation's work force for the projected 21st century work place. The Secretary of Labor's Commission on Achieving Necessary Skills (SCANS) in its 1992 report concluded that the future work place will demand "workers who have a solid foundation in the traditional basic academic skills, in the thinking skills necessary to put knowledge to work, and in the personal characteristics that make a worker confident, trustworthy and responsible" (SCANS pp. 5-6). Literacy skills sought by the 21st century employer will include accessing (reading, listening, and researching), thinking (discriminating, analyzing, interpreting), and communicating (writing, speaking, presenting) (Hill, 1992). The American worker must be able to productively use technology, process information, understand systems, work on teams, and allocate resources. Basic skills, such as literacy, thinking skills, and favorable interpersonal skills serve as the foundation for acquiring the competencies required in the work place (SCANS, 1992).

The United States suffers from an absence of standards for these basic skills, particularly in the area of literacy. At the end of World War II, a "fourth grade education" was the common measure; by 1965 an "eighth grade education" was considered literate (Conference Board, 1990). There is, however, no agreement on skills standards for "eighth grade education." The following comment by a literacy authority is illustrative of a prevailing "expert" attitude toward a literacy standard: "There should be a plethora of definitions, each appropriate for a specific community at a particular time" (cited by Peterson, 1989, p. 39). Such vagueness in definition leaves many parents, educators, and employers uncertain as to what skills to expect from students.

By contrast, Great Britain, Japan, and Germany, have nationally standardized tests which identify and measure specific work place competencies. For example, in Great Britain, all students take comprehensive exams at age 16. Those who pass are given a General Certificate of Secondary Education (GCSE). The GCSE is graded from "A", the highest level of proficiency, to "G", the lowest level. GCSE results are provided to universities, parents and prospective employers. Because they are standardized, students, employers and parents know exactly what skills are measured and the extent to which they have been mastered.

The U.S. has no comparable assessment system for basic skills of the work place. Although many U.S. employers insist upon a high school diploma or G.E.D. equivalent for employment, they do not value the educational level it represents: A high school diploma does not guarantee literacy or attainment of other basic skills.

**Public School Financing**

Public school financing and funding inequity among school districts is a major roadblock to systemic reform. In most states local property taxes provide about 50% of public school funds, with about 45% being supplied directly by the states, and the remainder provided by the federal government. Decreasing federal dollars and state aid, along with plunging real estate values has put many school districts into financial straits. The public has not, in general, been willing to pay more taxes to fund education.

Funding inequity among school districts hampers reform efforts. Disparities in property values causes inequalities in the expenditures per pupil ratio, and reformers have sought to equalize school financing methods through the courts. Some have been successful, as courts in over ten states have declared that existing school financing methods are unconstitutional (Henkoff, 1991).

Public education has been buffeted by combinations of decreasing revenue, weakening public support, and invalidation of current financing plans. Most states and school districts have responded to financial crises with a mixture of budget cuts and tax increases. Many of the educational budget cuts have centered on the staples of the 1980s reform movement: reducing class size, upgrading facilities, building new schools, increasing teacher salaries, and expanding the breadth of course offerings and extracurricular activities. These budget reduction targets are simple reactions to funding shortfalls, and are not necessarily part of restructured school financing plans. The districts that have been able to cope with financial crises have been those in which the community has been heavily involved in the decision

making process.

Often, however, decisions about school funding and education priorities are made with minimal community input. School boards and school administrators frequently allow only limited involvement of parents or students in decision-making. This situation is exacerbated in urban communities, where parental involvement is absent in many aspects of community and school activity and parents often do not possess the political power to influence board decisions.

**Urban School Challenges**

Inequity in school financing plans is but one of several major problems confronting public schools in urban areas. Poverty, violence, drugs, inadequate facilities and resources, and a poor quality of instruction are simply the most obvious. The performance results of students in urban schools reflect this situation:

- Baltimore. According to State Department of Education statistics, city public schools did not meet Maryland performance standards in attendance and, for students being initially assessed in reading, mathematics, writing, and citizenship.

- Washington, D.C. Local press reporting revealed that combined SAT scores for the district in 1992 were 705, as compared with 977 for neighboring Fairfax County, Virginia, and 899 for the nation. The overall school absentee rate in 1990 was more than 10%, with the attendance rate for high school only about 82%. The high school dropout rate for the District is more than 20%, ranking at or near the bottom of the country.

- According to a Gallup poll, inner city teachers report significantly greater instances of students requiring constant discipline, lacking basic skills, or involved in violent incidents in school.

Increased funding is not the sole issue with respect to improving inner city schools. Washington D.C. has seen its public school enrollment drop from 146,000 in 1977 to 80,000 today. Accompanying this decrease in enrollment has been an increase in expenditure per pupil to $8900, significantly higher than neighboring Fairfax County's $6300. New financing plans thus must be accompanied by administrative restructuring, new curriculum, teacher and instructional improvement, and emphasis on values and family issues.

**Social Issues**

Several social issues hamper education reform efforts. For many school districts, school reform and social reform are joined.

Many schools, both inner city and suburban, are beset by drug use and violence. Security guards, metal detectors, and discipline are major concerns of parents and school teachers. Basic survival has become a major concern of school teachers. An increasing number of children from disadvantaged, or uncaring families, arrive at school hungry, with

severe intellectual, motor development, or psychological problems. These children not only fail to learn but can disrupt the classroom learning environment.

The disintegrating social community structure is a tremendously significant factor contributing to the decline of our urban schools. Economic development in our cities is critical to repairing this structure and bringing about social and school change. Urban renewal and revitalization are necessary to motivate children to succeed in school, and to provide an improved tax base to support schools.

Other factors, centering on the family, have had an equally dramatic affect on the character of our educational system. The 1991 census found that 17% of white, 31% of Hispanic, and 52% of black families were headed by a single parent. The percentage of women in the U.S. work force with children under the age of six has increased 26% in the last two decades to reach 60% in 1990. Additionally, women in over 56% of all two parent families have also entered the work force (Children's Defense Fund, 1992). Not only does this make the subject of quality pre-school more critical, but the role of the family in education has been radically altered. Mothers, who typically tutor and motivate their children to learn, now have less time to devote to this critical activity.

The changing composition of our high school classroom, and of the work force in general, will compel educators to modify the way they organize and teach. Between now and 1999, high school graduating classes will have a higher percentage of females, who frequently find only low-skilled, clerical jobs after leaving school. Further, each class will have an increasing number of minorities and immigrants who are graduated from often underfunded and understaffed school systems. Finally, each graduating class will be smaller in size nationwide (Conference Board, 1990). In the American work force, non-whites, women and immigrants will make up more than five sixths of the new workers between now and the year 2000 (Johnston, 1987).

The emerging trends raise the issue of family influence on educational achievement to the forefront. The controversial Coleman Report in 1966 concluded that family and home environment, instead of school quality, was the primary determinant of educational achievement. This conclusion was supported by a U.S. Office of Education study published in 1975, which stated that student-parent expectations of school performance was an important factor in a student's success in school. Regardless if one accepts the findings of the Coleman Report, it is clear that the increasing disruption of traditional positive parental influence on their children has had a negative effect on student academic achievement.

Yet, while our education system has been acknowledged by many experts, and parents, to be inadequate, American parents show a high degree of satisfaction with their childrens' academic performance. Studies have concluded that American parents place less emphasis on academics than their Asian counterparts, and are content with a lower level of achievement (Stevenson, 1993). Figure I shows, for example, that American students spend less time in school, on academic activities, or homework than their counterparts in other industrialized nations. The implication of these findings is sobering: the family is a tremendous influence on students' performance, yet it appears that American parents don't expect much from our children compared to most other industrialized nations. Instead, they blame students' low scores on poor teachers or unstimulating courses. *Most Americans*

*believe that education is the responsibility of the school rather than the student.*

U.S. high school students do not appear to be as personally motivated for educational achievement as children in many other countries. U.S. students can pass through high school and still manage to attend a state university with minimum achievement. Additionally, their high school diploma is frequently an attendance certificate. There is no penalty for minimal performance in high school unless one's goal is entrance to a prestigious university. However, when the time comes to find a good, high-paying job, they are unemployable.

**Education effort in:**

| Hours per week | Minneapolis USA | Sendai Japan | Taipei Taiwan |
|---|---|---|---|
| Academic activities in class | 20 | 33 | 40 |
| Mathematics | | | |
| First grade | 2.7 | 4.0 | 6.8 |
| Fifth grade | 3.4 | 7.8 | 11.7 |
| Homework | | | |
| First grade | 0.8 | 3.7 | 8.3 |
| Fifth grade | 3.8 | 6.3 | 12.9 |

Source: National Science Board

Figure 1

### Summary

Our study concludes that the most challenging problems facing our education system are: fragmented authority and control; curriculum and teaching methods based on outmoded "Taylorism" pedagogy; lack of nationally standardized, comprehensive, well understood tests that measure required Workplace 2000 skills; inequalities in school financing leading to inadequate facilities and resources; and a multitude of social problems from poverty to drugs to violence and multi-cultural language and behavior disparity. *In short, in the U.S. educational system, teachers are functioning as social workers, policemen, or parents as much as they are as educators.*

## SYSTEMIC INTERACTIONS

Because of the decentralized nature of our system, government officials, educators, parents and businessmen have not pooled their resources to attack the issues described in the preceding paragraphs. The result is a series of systemic disconnects that make a child's education a disjointed experience.

Our systemic problems begin at the preschool level. A 1991 survey found that 35% of U.S. children were not ready to enter school (Boyer, 1991). Their preschool experience did not provide them adequate intellectual, social, and emotional stimulation. Many children never recover from this slow start.

Systemic shortfalls extend to work place preparation. Our system is also failing to graduate students prepared for gainful employment. The wages, benefits, and working conditions of the 75% of Americans who do not graduate from college are declining (in real terms). In most school districts no clear vocational path bridges the school-to-work gap for

the 75% of our youth who do not graduate from college. The business community views with alarm many of our educational ills. However, both in partnerships with schools and with its own work force, their efforts are also piecemeal.

Retraining of the American work force remains neglected by international standards. *Eighty percent of American workers for the year 2000 are already in today's work force; yet less than 10% of all front-line workers in American industry are provided any training* (SCANS, 1992). Thus we have a system in which many students enter at a disadvantage, receive little guidance or basic skills training with respect to school-to-work transition, and are not retrained by the company that employs them to upgrade their skills.

**Work Place Training**

Over half of all high school graduates never attend college. Of the 44% who do enter college, 19% drop out. Therefore, a full 75% of high school graduates do not earn a college diploma. Most high schools, however, emphasize college preparation in their curriculums and counseling services, and we have no competent school-to-work transition curriculum. Moreover, the business community has not yet compensated for this schoolhouse deficiency by instituting industry-wide training programs such as those which exist in European countries. Finally, there are only limited training opportunities available for those who have dropped out of the system. Each of these three problem areas is discussed in detail below.

**School-to-Work Transition Curriculum**

During our studies in Great Britain and Germany we discovered that each of these countries had national programs of school-to-work transition for students not bound for college. While the details of each program vary, their intent and strong emphasis on national standardized qualification tests are remarkably similar. In Great Britain, the government contracts with independent companies which provide transitional work place training for students who leave school. In Germany, government and industry form a partnership so that the acquisition of knowledge and skills (provided in public schools) is linked to the job experience training (provided by industry).

In both countries students take national exams to determine their qualifications and aptitudes. After consultation with parents and teachers, students elect to pursue university, or another form of higher education, or to enroll in vocational training. Upon completing vocational training, students are again tested on national, standardized tests and certified as qualified for the work place. Tests are developed in collaboration with industry, thus prospective employers are able to assess the skill level of any potential employee.

A striking feature of the school-to-work programs of both countries is an effective partnership between government and industry which either provides the standards for training (Great Britain) or conducts the training (Germany). Additionally, in both countries, the student takes an active role in the training process -- he or she is responsible for learning. This relationship is illustrated perfectly in Figure 2, a chart presenting the Mercedes-Benz Training program.

The U.S., by contrast, has no program of standardized tests or government/industry partnerships. We are the only industrialized country in the world without a formal school-to-work transition program. The American response to the need for such a program has been locally developed "tech-prep" education. Formerly labelled "vocational education", the traditional auto shop/home economics focus is shifting to more technical fields, such as robot technology, medical technology and news broadcasting. North Carolina has a strong statewide program, for example, in which high school graduates can move directly into the working world. Community colleges, by linking tech/vocational courses in grades 11-12 with 2 years at a community college, have also become a focal point in the school to work transition. Many of their programs integrate work experience into academic courses.

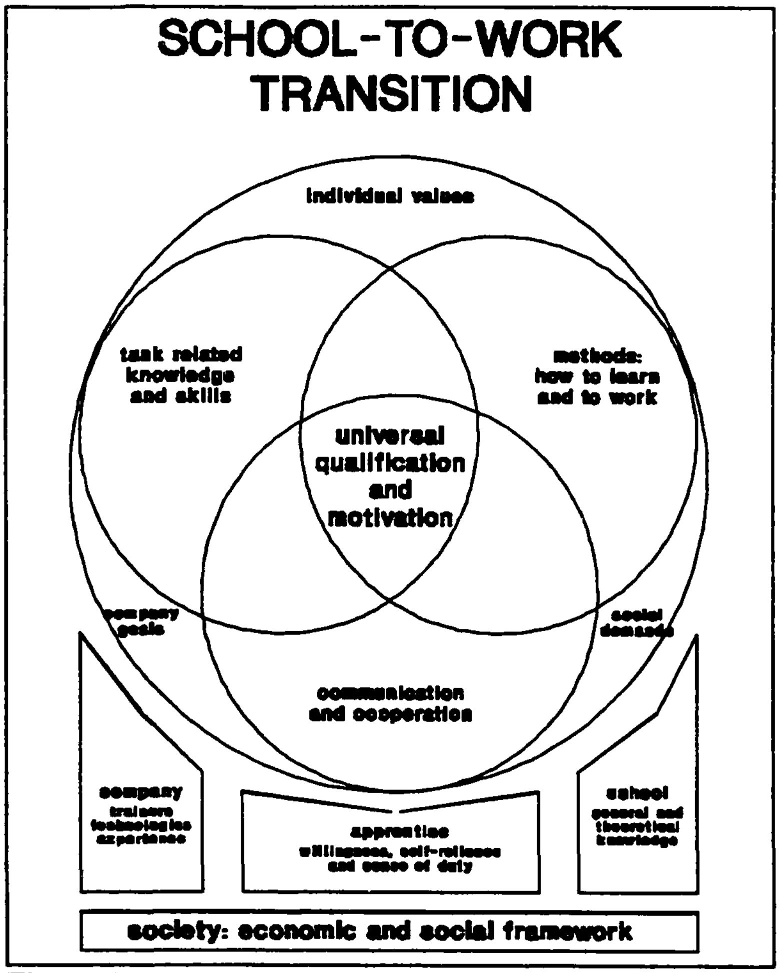

Figure 2

Despite the success of many of these programs, a formal large scale school-to-work transition program is absent. Figure 3 lists the 10 occupations forecast to grow the most in the next 12 years. These jobs will require school-to-work training, as will 75% of all new jobs in this time period.

**Training for Workers Already Employed**

As noted earlier, less than 10% of all front-line workers in American industry are provided any training. Training budgets in Germany and the U.S. are roughly comparable (between 2.5 and 3% of the total work force payroll). However, in Germany, the bulk of training dollars are spent for apprenticeship and front-line worker training (SCANS, 1992). In the U.S., by contrast, 80% of industry training dollars are spent for executive or senior management training. Poorly educated workers can expect little training or support from employers. And employers, seemingly reluctant to train front-line workers, can expect little from those workers. The net result, predictably, is lower productivity and decreased economic vitality.

**Fastest Growing Occupations (1990-2005)**

| Occupation | Employment | | Numerical change | Percent change |
|---|---|---|---|---|
| | 1990 | 2005 | | |
| Home health aides | 287 | 550 | 263 | 91.7 |
| Paralegals | 90 | 167 | 77 | 85.2 |
| Systems analysts and computer scientists | 463 | 829 | 366 | 78.9 |
| Personal and home care aides | 103 | 183 | 79 | 76.7 |
| Physical therapists | 88 | 155 | 67 | 76.0 |
| Medical assistants | 165 | 287 | 122 | 73.9 |
| Operations research analysts | 57 | 100 | 42 | 73.2 |
| Human services workers | 145 | 249 | 103 | 71.2 |
| Radiologic technologists and technicians | 149 | 252 | 103 | 69.5 |
| Medical secretaries | 232 | 390 | 158 | 68.3 |

(Numbers in thousands)

**Figure 3**

## Drop-Out Recovery

Many of these students have such poorly developed skills and knowledge that they can find only menial work, at best. Others have no work opportunities at all. A few of these drop-outs may find their way into federal or state training programs like Job Corps (for the chronically unemployed or disadvantaged worker). However, the programs are small, the cost per worker/trainee is very high and the results mixed. The key to any successful program lies in a government-business partnership, similar to the ones found in Germany, where specific training for specific work opportunities are tied together.

## PERFORMANCE

This study has thus far focused on deficiencies in the structure and conduct of our nation's educational system. This section will examine performance information to determine if the case against America's education system has been overstated.

### Standard Performance

It is widely accepted as fact by the American public that our educational system as a whole is not producing properly skilled or literate candidates for the work force. *The number of functionally illiterate adults is normally reported as between 25 and 50 million and the number of young adults leaving school who are capable of finding anything more complicated than menial labor may be less than 50%.* A National Association of Manufacturers survey of

360 companies, for example, found that 50% reported serious deficiencies in basic math and reading skills among their workers (Segal, 1992) and SCANS theorized that "more than half our young people leave school without the knowledge or foundation required to find and hold a good job" (p8). A question that surfaces, however, is whether the products of our educational system have deteriorated in quality, or have the standards of the marketplace been raised? The following comment by Marc Tucker, former Executive Director of the Carnegie Forum on Education and the Economy, is pertinent:

> Our educational system, on balance, is performing about as well now as it was 10 or 20 years ago... What America has got to understand is that the standards that were in place 5 years ago, 10 years ago, 20 years ago, and 30 years ago in this country are utterly irrelevant (cited by Subcommittee on Education and Health, 1988, p14).

The answer to the question, then of whether our education system has faltered is also irrelevant; it only matters that it has not kept pace with the evolving work place.

**Performance Measurement**

The issue of national standards is one in which a lack of a uniform approach to education is evident. As noted earlier, there is currently no reliable means to measure performance across the system. Although the National Assessment of Educational Progress (NAEP) has established the means annually to compare regions of the country and assess relative progress nationally, there is no way to objectively evaluate individual student performance, compare one school to another, one state to another or any of these to an objective standard (Finn, 1991). Despite the scarcity of reliable performance data, information is plentiful to corroborate the assertion that the system has not kept stride with the workplace. A wealth of such information exists, and several of the more striking facts follow:

- According to a 1986 NAEP survey, only 56% of 21-25 year olds holding a high school diploma could read at an eleventh grade level.

- Illiteracy among minority students is as high as 40%. By the year 2000, minorities will make up a majority of the school age population in 10 states (Perry, 1988).

- Most elementary students spend most of their 40 minute math classes learning skills needed by a 1940s clerk (Bruden et al, 1992).

- In 1986, American high school seniors ranked 9th in standardized tests, 11th in chemistry and last in biology among 13 countries (Perry, 1988). In 1988, American students ranked 12th out of 12 countries on an international ETS math test. In 1989, 50% of Japanese students performed as well as the top 5% of American students on an international math test (Toch, 1993).

- U.S. students rank 49th in literacy when compared to students from 158 nations (Motorola, 1993).

It is apparent that not only are we not educating students to meet the requirements of the work place, we are falling behind our international competition.

**Goals 2000**

Among the multitude of independently enacted reform efforts, a set of widely supported concepts have begun to emerge. In 1989, at the "Education Summit", in Charlottesville, Virginia, President Bush and the fifty state governors agreed on a set of national educational goals, now known as America 2000. These goals and our success in attaining them are discussed next. Inspection of our progress in meeting these goals, as enumerated by the National Education Goals Panel in 1992, yields no reason for optimism.

## AMERICA 2000 GOALS AND RESULTS

**Goal 1** - ***All children in America will start school ready to learn.*** There is still no direct measure of the nation's progress toward this goal. (Independent studies show that 20-30% of U.S. students enter school from poverty, improperly nourished, sick, neglected, with little intellectual stimulation (Perry, 1988)).

**Goal 2** - ***The high school graduation rate will increase to at least 90 percent.*** In 1991 the overall high school completion rate was 85 percent for 19-20 year-olds and 23-24 year olds who received a high school credential. (Independent studies show that a quarter of students entering high school now will fail to complete it [Conference Board, 1990]).

**Goal 3** - ***American students will leave grades four, eight, and twelve having demonstrated competency in challenging subject matter including English, mathematics, science, history, and geography; and every school in America will ensure that all students learn to use their minds well, so they may be prepared for responsible citizenship, further learning, and productive employment in our modern economy.*** The NEGP provides no data to report progress on this goal. Its Goals Reports lists an increase in the number of students taking examinations in the core subjects in 1991 but does not review results of the examinations. It does state "as a nation, we have never determined what it is we expect all students to know and be able to do" and calls for national content and student performance standards.

**Goal 4** - ***U.S. students will be first in the world in science and mathematics achievement.*** American 13 year olds were outperformed by students in Hungary, Korea, and Taiwan in three of four science areas and by students in Korea, Switzerland, and Taiwan in mathematics in 1991 assessments.

**Goal 5** - ***Every adult American will be literate and will possess the knowledge and skills necessary to compete in a global economy and exercise the rights and responsibilities of citizenship.*** The report shows that 97 percent of young adults have mastered the most basic functional literacy skills (NEGP, 1992). (Functional literacy is defined as a person reading between the fourth and eighth grade levels, the minimal level needed to survive. This statistic, therefore, is relatively meaningless. A more meaningful indicator is that

only 56% of 21-25 year olds holding a high school diploma can read at an eleventh grade level (Conference Board, 1990).

**Goal 6** - ***Every school in America will be free of drugs and violence and will offer a disciplined environment conducive to learning.*** The report cites a drop in alcohol and cocaine abuse among seniors from 1980-1991. Marijuana use remained constant. (An April 1993 report by the University of Michigan's Institute for Social Research, found increases in LSD use among seniors and inhalants use by eighth graders.) A pattern of yearly increases in instances of student victimization at school was maintained from 1980 to 1991.

**Summary**

Summarizing the performance of the education industry is a complex task. It is undoubtedly clear, though, that the quality of education being provided our students trails our foreign competitors; it does not meet the business community's needs; it contributes to social problems, since individuals who are deficient in basic skills are more likely to be school dropouts, teenage parents, jobless, welfare dependent, and involved in crime (Berlin and Gum, cited by the Conference Board, 1990); and for the political reasons noted earlier, educational leadership has been unable to establish or measure standards of performance for students and teachers.

## OUTLOOK

The country's educational "problems" defy simple remedies. These problems are not manifested solely in the educational arena, and thus numerous solutions and reform measures are being attempted across the spectrum of the country's business, social, and governmental institutions. There is, however, no formal delineation of authority and responsibility to mobilize our public and private institutions to publish and implement policies to correct shortcomings. *It is clear that a nationwide reform movement must involve the full range of social, cultural, religious, labor, and professional organizations* (Ahmed, 1992). Society has experienced a major paradigm shift from the socially homogenous agrarian and industrial past to the socially diverse, information based present. We must make a corresponding systemic shift by linking our education, social, health, family and industrial resources.

This country has not yet made such a systemic shift. To repeat our central thesis, there is no coherent, comprehensive national plan that has won national acceptance. There are only pockets of excellence in districts and states attempting reform. However without a national systemic shift, the quality of our educational system's products will continue to deteriorate or at best, churn out the same student who is not on the whole suitable for the future work place. According to NAEP, each high school class is less literate than its predecessor, and the levels of literacy of our students are not adequate for maintaining leadership in a technological society. The fastest growing occupations require employees to have much higher math, language, and reasoning capabilities than do current occupations. If present trends continue, by 1995 14 million Americans will be unprepared to seek available jobs (Hill, 1992) and by 2000 75% of adults may lack the reading and mathematics knowledge required for any but the lowest level, lowest paying job (Peterson, 1A, 1989).

## STRATEGIES FOR REFORM

This report has emphasized the fragmented nature of America's educational reform movement. The movement does indeed appear to be random and uncoordinated, but there are several guiding principles that serve as the foundation and vision for the reformers efforts.

The six educational goals agreed upon in Charlottesville in 1989 by the nation's governors were reviewed in an earlier section of the report. In July 1991, the SCANS report, which was cited earlier, developed five necessary work place competencies and three educational foundations. In 1990, Ira Magaziner's Commission on the Skills of the American Workforce proposed a new educational structure in their report America's Choice: High Skills or Low Wages. In 1991, President Bush challenged business to form the New American Schools Development Corporation (NASDC). The Clinton administration inherited the America 2000 strategies and goals and has incorporated them into the key provisions of its Goals 2000: Educate America Act recently submitted to Congress. Goals 2000 seeks to set into law the six National Education Goals of the Bush administration, reaffirming the target year for attainment of 2000. In many respects, the Clinton strategy mirrors the Bush effort, through pursuit of a bottom-up approach of voluntary standards for attainment by states and local communities, monitored by federal panels and councils. Notably, national guidelines will be set for so-called "opportunity-to-learn standards" which address the quality and availability of curriculum, instructional materials, and technologies. The act seeks to make $393 million in federal funds available directly to states for development and implementation of education improvement plans down to the individual school level in support of Goals 2000.

Despite its claim to be a "first step toward turning a nation at risk into a nation on the move," Goals 2000 is another in a familiar series of national efforts to encourage education reform efforts at the state and local level. The relatively tiny percentage of federal funding for education that is available at the local level will continue to limit federal clout in imposing strict national programs to meet stated national goals. In addition, Goals 2000 makes a familiar appeal to family and community involvement, but fails to acknowledge the education and social welfare policy integration which must be a part of systemic education reform.

Nevertheless, federal leadership has led to progress at the local level. Many individual schools and coalitions throughout the nation are implementing the national goals and strategies through a variety of individual education reforms. A detailed review of the initiatives being advanced by the educational establishment and business community is contained in Appendix I to this report. Several of the most notable reforms being pursued with the focus upon the individual school as the unit of change are highlighted.

## GOVERNMENT POLICY INITIATIVES AND OPTIONS

This report has in several instances stressed the decentralized nature of America's educational system and noted the lack of comprehensive reform. Restructuring -- real change -- is being initiated throughout the country, but a majority of American schools still conform to the industrial "factory" model. Government can address the issues, but change from Washington or state capitals, in the form of mandated programs or new layers of bureaucracy, would be resisted and could be ineffective. Federal, state, and local governments must

encourage, incentivize and initiate specific educational reforms and lay the groundwork for long term, systemic restructuring. Mutually reinforcing action is required at all three levels to allow true reforms to take hold.

Although not listed below as government options, each level must take action on issues affecting the family's ability to play a meaningful, positive role in education. Stricter compliance with child support orders; improving the availability, affordability, and quality of child care and pre-school; and using welfare benefits as incentives for attending school or ceasing to bear illegitimate children are all measures that deserve careful consideration. Clearly, this is where executive leadership must take the lead by reemphasizing the value of the family in creating a productive educational system. On the positive side, the current partnership of the Secretary of Labor and Secretary of Education has focused attention on the educational system and its needs. The addition of the Secretary of Health, Housing, and Social Services would strengthen the partnership and give proper attention and weight to the importance of the family.

This section of the report will review the major initiatives and options available to the nation's public policy makers.

**Federal Initiatives/Options.**

The federal role in educational reform must be one of strong leadership. The nation's attention must be focused on this crisis, not necessarily in terms of new programs or funding, but in developing a sense of activism in families, communities, and businesses. A collective sense of responsibility for the system's failures would constitute significant progress. Promoting Goals 2000: Educate America, as the nation's educational vision, legislating a broad national framework and supporting guidelines, providing targeted funding, and encouraging consensus on national standards are measures appropriate for federal action. Specific policy options are listed below.

**Option 1. Exhibit strong coordinated executive leadership.** Forcefully communicate the importance of educational reform and build public support. The President must personally describe society's paradigm shift and stress the corresponding need for a new educational system. The links between education, worker skills, productivity, teamwork, competitiveness, and high wages must be stressed by the President and all cabinet members and bureaucracies of each cabinet. SCANS must be emphasized as the way America's educators and corporations will do business. Corporations, private organizations like NASDC, parents, and communities must be challenged to contribute time, energy, and money to local reform efforts.

**Option 2. Dedicate resources to establishing national, world class academic standards, skill certifications, and criterion-referenced assessment tools.** Joint commissions, such as the National Council on Education Standards and Testing (NCEST) described in the Appendix, are an effective means of establishing standards and assessment tools. The standards must remain voluntary (not mandated by Washington). Activism by parents, communities, and businesses will force their adoption. Progress in this field has been evident, as most states are choosing to implement the NCEST approved model.

**Option 3. Legislate a national education framework and support it with appropriate funding.** The legislation must incorporate future flexibility and delegate authority for implementing detail to states and communities. Provide incentives by linking federal funds (currently 6-7% of national elementary and secondary education budgets) to specific reform efforts. Key elements of an education legislative agenda are:

1. Goals 2000: Educate America Reform Bill and "seed" funding. Incentivize reform and conversion to New American Schools Design by providing start up, or "seed", funding to communities.

2. Elementary and Secondary Education (ESCA) Act Reauthorization Bill. Improve equity through increased funding of programs targeted for urban schools serving large numbers of disadvantaged youth.

3. School to Work Youth Apprenticeship Legislation. Develop with business, labor, civic and educational leaders a national apprenticeship program to provide non - college bound students with relevant training in an alternative environment and guaranteed skilled jobs upon graduation.

4. Existing Workforce Training. Provide incentives/ assistance to raise educational levels of existing workforce to new national standards. Specifically: 1) continue tuition loans to individuals taking courses geared to developing skills to meet new standards (SCANS,etc); 2) provide tax incentives to encourage industry training and education of workers; 3) restructure social safety net to emphasize training the unemployed; 4) encourage business and school partnerships focused on resources dedicated to workforce training

5. National Service Trust Fund Bill. Establish a National Service Trust Fund (civilian G.I. Bill) to provide college education for all. Payback could be a small percentage of income over time or through community service as teachers, health care workers, etc.

6. Head Start Revitalization. Full funding of effective, well managed basic support programs would help level the entry point for disadvantaged pre-schoolers. Head Start's goals are laudatory, but full program evaluation of Head Start is a must to determine if it is yielding any long term benefits and, if not, what corrective measures are required to enable it to achieve its goals.

**State Initiatives/Options**

Action at the state level is critical to all education reform programs. Authority to determine academic standards, curriculum changes, school graduation requirements, salaries and certification requirements for teachers rests with states.

Specific initiatives/options for reform at the state level include:

**Option 1. Restructure school financing plans to ensure all schools receive equitable resources.** New financing plans must be linked to the performance of schools as a

whole and not consist of hasty and ill-conceived budget cuts and raised taxes. Financial incentives, in the form of bonuses for increasing graduation rates and scores on competency tests, should be incorporated. Kentucky has initiated bold reform in this area. (See Appendix).

**Option 2. Achieve consensus on how to implement national educational goals, standards, and assessment tools.** Serve as the coordination point for spreading reform initiatives throughout the state. Explore implementing financial incentives to enforce accountability.

**Option 3. Improve teacher quality by requiring more rigorous academic training and intensive, hands on practice teaching prior to state certification.** Institute teacher apprenticeship for periods of 1-3 years. Require periodic reevaluation/recertification. Implement teacher performance incentives. Add highly trained technical personnel to the declining teacher force through an alternative certification program targeted at dislocated military personnel.

**Option 4. Institute curriculum reform, particularly in the area of literacy and basic skills instruction.** Curriculum objectives should be mandated. Close coordination with the pursuit of increased teacher professionalism, outlined in Option 3, is vital.

**Local Initiatives/Options**

Regardless of the volume or specificity of reforms enacted at the federal or state level, *the local school district or individual school stands out as the agent of change in educational reform.* If all reform measures are evaluated from the perspective of their impact on the teacher -student interface, then the district and school truly are the determining factors in all reform efforts.

The Educational Initiatives section of this report provided detail on many of the reforms being executed at the local level. Listed below are categories of reform proposals best suited for enactment at the school district or individual school.

**Option 1. Solicit parental, community and business involvement in developing and implementing reforms.** Values, behavioral problems, adult literacy programs, basic skills training, and health/social services issues are examples of topics that should be tackled in this forum.

**Option 2. Prepare proposals for federal, state and private grants.** Construct partnerships with educational reform organizations and businesses to sponsor innovative projects.

**Option 3. Implement the following reforms, most of which were discussed in "Strategies for Reform":** 1) school choice; 2) new curricula; 3) personalized learning environment; 4) expanded use of technology; 5) revised assessment methods; 6) restructure teaching profession; 7) entrepreneurial teaching climate; 8) improved access to pre-school, college, and school-to-work transition programs.

## CONCLUSION

This report may appear to advocate two contradictory principles: the American educational system is too decentralized, allowing needed reforms to languish in isolated pockets, yet the individual school, not governmental institutions, is the most practical unit of change. These principles are in fact compatible. It is the decentralized nature of education that has allowed bureaucracies and interest groups resistant to reform to develop and flourish. These obstacles to reform have ignored what must be their raison d'etre: enhancing classroom learning. In describing failures of certain aspects of the Bush administration's education plan to clear Congress, David Kearns observed that "A number of people thought that winning and losing" was more important than improving schools.

*A consumer's revolt is the key to accomplishing comprehensive nationwide educational reform.* Families, community organizations, and businesses must acknowledge the system's, and their own, failures and demand a better product from their local schools. The federal government must lead this effort. All parties must accept responsibility and become willing to engage in meaningful, informed discussions and policymaking on such taboo topics as unions, values and school choice. *Only through community, parent, and corporate activism can schools truly be held accountable, and only in that manner can the nation accomplish reform.*

## APPENDIX I

This appendix highlights some of the more prominent reform initiatives attempted by the educational establishment and the business community. Many of this report's options for reform are based on evaluations of the results of these programs.

## EDUCATION INITIATIVES

***Curriculum Management.*** This report has drawn attention to the issue of whether schools are in fact teaching the subjects that need to be taught to our 21st century workers. Some school districts have decentralized curriculum development and have ceded to individual schools the authority to develop and manage what they teach. We have concluded that curriculum development should be closely tied to community requirements, necessitating input from parents, community organizations, and employers.

At the core of much of the curriculum restructuring movement is an approach (whole language) that centers on content and process rather than on skills acquisition and form (Reyes, 1992). The value of a teacher's professional judgement is stressed and flexibility in materials and activities is encouraged. Learning is treated as problem solving, and literature based instruction, rather than adherence to formal, standard reading textbooks, is emphasized in teaching literacy. Use of standardized tests is resisted, and principals and teachers frequently have the authority to develop their own curriculum.

An interesting approach to curriculum development is being utilized by Virginia's Fairfax County. Operating under a philosophy that curriculum development does not belong solely in the hands of principals or teachers, Fairfax County employs a Department of

instruction to manage the process and involves administrators, principals, teachers and the community, which is the user of the schools' product, in the effort. A curriculum constructed by informed stakeholders, the procedure followed by Fairfax County, appears to be more in tune with a need to upgrade our education.

***Teacher Professionalism.*** The preceding review of curriculum development illustrates the increasing role of teachers in much of the new focus on curriculum development. The SCANS report states that teachers, administrators, and education professors need retraining for new pedagogical skills, new instructional management skills, and knowledge and understanding of the principles of high performance (SCANS, 1992). A major systemic flaw with many new teaching methods is that there is frequently no formal training provided to teachers on how to effectively apply new methods. The training for whole language instruction, for example, has been short term and "virtually assures that only the rudimentary elements of these theories can be presented" (Reyes, 1992, p429). There has been no nationwide implementation of whole language instruction, no formal training of its practitioners, and no evaluation of its effectiveness. Encouragement of learning methods in which higher order schematic thinking skills are stressed and an active learning environment is developed are great ideas. Still missing are formal teacher training and program evaluation.

Leaders in innovation such as Fairfax County have attempted ambitious programs in these areas. The County, for example, discovered that retrained teachers instructing from old textbooks had students who achieved higher math scores than those being taught by teachers not in receipt of training but utilizing new textbooks. The County's Superintendent of Schools Robert Spillane has also been a champion of merit pay for teachers, viewing it as a crucial component of enforcing teacher accountability and enhancing teacher professionalism.

The subjects of teacher accountability and performance incentives such as career ladders and merit pay are contentious and are frequently found at the center of teacher professionalism debates. Teachers' unions and many administrators believe that competition is counterproductive to the development of collegiality and harmony necessary in teacher support systems. However, it appears that teacher assessment (testing) and performance linked pay are growing in popularity: more than 20 states now have such programs and seven more are developing incentive plans.

Teacher resistance to assessment and performance initiatives has perhaps damaged their drive for acceptance as a credible profession. Union rejection of merit pay, insistence that teachers be granted control of curriculum, and willingness to strike for higher pay are not seen as characteristic of "professionals". Teachers unions do, however, perform a vital function. Fairfax County's teachers salaries are well below the local average, primarily because of the lack of a union. The public, however, has yet to see a clear correlation between salaries and performance and professionalism. Parochial schools salaries are well below public school salaries, on the whole, and the community views these schools as exceptionally capable. A thrust of union activity toward improving teacher expertise would likely gain great support.

***Standards/Assessment.*** New curriculums and new teaching methods have been accompanied by new assessment methods and a review of established standardized tests. Alternative assessment portfolios, minimum competency tests, standardized skills tests,

performance based progression, and voluntary national standards pegged to world-class standards are the more prominent elements of a new approach to evaluating our students' progress.

There are two philosophically opposing camps marked by their fundamentally different views of education. On one side are those who stress the importance of an education system characterized by formal inputs, processes, feedback loops, and measurable outputs. In opposition are those who take the child centered point of view. They assert that each person's education is a unique experience which cannot be reliably measured against a common standard nor should it be. Such a philosophy is manifested in the comment cited earlier concerning literacy standards. Opponents to national standards raise the specter of students in "assembly line" learning with standardized tasks functioning as the quality control while we produce a nation of robots. Standards/testing proponents hold to the view that standardized, multiple-choice testing can be used to efficiently measure some basic skills. The tests need only be improved.

The overall direction of the debate appears to be drifting to national content standards for history, geography, mathematics, science and English. Eventually, there will likely be standards developed for civics, general social studies, physical education and the arts. Heading the effort is a bipartisan task force of educators and legislators, the National Council on Education Standards and testing (NCEST). The task force functions as a guiding, not ruling, authority. It evaluates standards produced by the various task forces and registers approval if appropriate. NCEST approval of one set of standards and/or tests does not rule out the generation of others for the same subject area. The stated goal is to provide states and localities with a menu from which they can create the combination of standards and assessment means best suiting their needs while meeting national educational goals.

The National Council of Teachers of Mathematics has already developed and deployed standards for mathematics. Forty states are in the process of revising their math curricula to reflect the Council's standard. Various other professional groups, some with federal grants, are working on content standards for the other subject areas mentioned above. Projected completion of the various standards packages extend over the next two years with testing/assessment protocols to follow at an as yet undetermined interval.

The State of Maryland established the Maryland School Performance Program in 1989 to address the need for school performance standards. The program is a "comprehensive school improvement approach to accountability" and features standards in data based goals, in areas ranging from mathematics assessment to dropout rate, that are to be achieved within five years. An annual report is issued for each school, school system, and the state so that students, faculty, parents and the community can measure progress (Maryland Department of Education, 1993).

Formal promulgation of national standards, even voluntary ones, constitutes a concrete step to bringing structure to what we expect our children to learn. Conflict with those favoring autonomy for individual schools and teachers is an obstacle: whole language advocates, for example, regard standardized tests as relics from a primitive era. Reconciling these differences, bringing a dedicated, concerted focus to efforts to improve nationwide student performance, is critical.

***Community/Parent Involvement.*** Involving the community in efforts to upgrade schools is vital to reform of the educational system. This involvement takes many forms, from family literacy programs to partnerships with businesses, and provides several benefits.

Efforts to make an entire family literate would yield significant societal benefits. There is documented evidence linking the literacy of parents with the size of their families, the mortality and nutritional status of their children, and the likelihood that they will enroll their children in school and that these children will then complete school (Ahmed, 1992). Additionally, the more literate an individual is, the less likely he or she is to be jobless, welfare dependent, or involved in crime (Conference Board, 1990). There are an estimated 500 family literacy programs in libraries, adult literacy centers, community agencies, preschools, elementary schools, and the workplace. The program claims to have helped parents support the literacy development of their children and improve their own literacy in the process. Of note, however, is the fact that schools that already have parent programs or strong parent organizations found the program easier to adopt than schools without a history of parent involvement.

Successful reform efforts have expanded community involvement efforts beyond standard parent-teacher organizations or family literacy programs. Fairfax County made parents an integral part of its focus on curriculum development, and Chicago has given school councils, with the majority of the board consisting of parents, the authority to hire and fire principals. Many magnet schools with selective enrollments, such as Fairfax County's Thomas Jefferson and Illinois' Math and Science Academy, engage in outreach programs designed to spread the word to parents and teachers about their curriculum and teaching innovations. SCANS principles, key to reorienting the planning processes and operating methods employed by educators, are being "sold" by the Massachusetts Department of Labor. They and DOE have formed an alliance, a rare occurrence in this field, to get communities to adopt SCANS and the features of America 2000. Most efforts in the industry, however, focus upon "one community at a time".

Families and community organizations that participate in educating their children effectively attack two of the major obstacles impeding educational reform. They bring more expertise to the educational policy-making arena, thus challenging systems that refuse to reform, and get parents to care about their children's education, thereby raising standards and hopefully contributing to easing of a small portion of our social problems.

***Restructuring School Financing.*** The urgent need to overhaul public school financing methods was stressed in an earlier section of this report. Many states are considering finance reform; Governor Schaefer of Maryland intends to name a commission to study the issue; but Kentucky stands out as a state that really did embark upon an ambitious reform effort. The Kentucky Supreme Court, in 1989, voided the state's property tax based school funding formula and declared all public education in Kentucky, " the entire sweep of the system, all its parts and parcels" to be a failure and unconstitutional (cited by Henkoff, 1991, p138). Kentucky has responded by charting a new course; by attempting a true reform effort. Among its features were increases in corporate income and sales taxes, mandating local taxation levels, and eliminating the state income tax deduction for federal taxes paid. In addition to its fiscal provisions, the state instituted bold reforms throughout the state's educational system. Bonuses were offered to districts that markedly improved performance, jobs were cut at the

State Education Department, district hiring power was curtailed, and schools were allowed more control over curriculum development. The most innovative proposal was the creation of school councils, made up of a school's principal, three teachers, and two parents, that assumed power previously held at the State Department of Education and School Board level. Kentucky thus did not approach the funding issue in isolation, but made it part of a wholesale review of the way the state conducted business. School choice, with its potential impact on public and private school financing, should be part of such comprehensive reviews.

***School Choice.*** School choice has formed the core of many reformers' plans for revitalizing education in this country. America 2000 featured choice as a major element of its strategy, proposing not only that students be free to choose which public school they will attend but that they be permitted to enroll in private schools at public expense. Block grants to be used on public and private school choice was deleted from President Bush's education proposals by the Senate. President Clinton's Goals 2000 advocates the promotion of public charter schools to increase choice among public schools. Certain provisions of this school choice philosophy have been implemented on local levels, and have generated considerable controversy with respect to constitutionality, funding, equity, and effectiveness.

The pro-choice movement has developed substantial support among conservatives and free market economists. The principle underlying their beliefs is that competition between and among public and private schools will cause improvement in all schools, regardless of location or type. "Parents could vote with their feet... Schools that respond to parents' wishes would thrive. Bad schools would wither and die" (Wornsop, 1991, p255). Opponents to school choice plans claim that if implemented they would increase, not remedy, inequity prevalent in the public school system. The top schools would attract the best students and left behind in the poor districts will be the "tenfold students who lose the parental commitment and community votes necessary to improve their schools" (Thomson, 1989, p33).

Proponents and detractors can each cite cases to substantiate their claims. New York City's District 4 has seen dramatic improvement since implementation of a district wide school choice program in 1974, but opponents point to increased funding and other district initiatives as the cause for change. Some formal research in the field has been conducted, however, and its conclusions support one of the major themes of this study. Mary Anne Raywid of Hofstra University, after a decade researching school choice plans, concluded that families with choice options become more involved, supportive, and satisfied and witness tangible improvement in their children's achievements (cited by Nathan, 1991).

Although there is not enough data available to form absolute conclusions on the ability of school choice policies to achieve their stated goals, there are guidelines that spell out how such policies must be implemented to be effective. Initially, the institution of a marketplace operation in public education would help make educators accountable to their constituents. The keys to any successful choice plan are making a wide range of schools with varied programs available to educators and students, ensuring that information about these programs is properly disseminated, concentrating especially on low income families. Additional steps include formally promulgating goals, prohibiting admissions on the basis of past achievement, making transportation available, ensuring money is allocated based on where students actually attend school, establishing procedures to implement racial balance, and modifying plans in midstream as required.

***Site-based Management.*** Site-based management, in its various versions, is an attempt to grant individual schools decision-making authority normally reserved for school district boards or superintendents. It is commonly found in the area of financing, in which a fixed percentage of base funding is allocated directly from districts to schools for them to expend as they see fit.

This subject again raises the question of governance of schools, discussed earlier in this report. School boards have had their authority erode over the last several decades, and they are not thrilled about the prospect of losing power to individual schools. The Chicago school council experiment mentioned earlier is one form of site-based management that has made the principal the agent of change in the school reform movement. Fairfax County has taken a contrasting approach, believing that a principal's focus must be on classroom instruction, not building or budget management.

On the whole, the site based management school of thought relies on the same reasoning expressed by many of the curriculum development, teacher professionals, and assessment reformers: provide as much authority and responsibility to individual teachers and principals as possible.

***Change the School Year.*** This report briefly mentioned that our students attend school less time than those of most industrialized nations. Japanese students spend 64% more time in classes (not counting the "cram" schools) than American children, and the Taiwanese have a longer year than the Japanese. The case for extending the American school year is a strong one. In a 1991 review of 100 research projects, a University of Illinois professor found that 90% of the time, student achievement rises with the amount of time in class (Toch, 1993).

Research also shows that during our long summer vacation, most children (especially disadvantaged students) regress educationally. Consequently, teachers have to spend one to four months every fall reviewing forgotten material, a large waste of resources. Los Angeles has solved this problem by keeping schools open year-round, with three short breaks between tri-mesters. Numerous reformers since A Nation At Risk was published have argued strongly for similar measures but the concept has yet to be embraced by the public (Kearns, Doyle, 1988).

***Restructuring.*** In addition to reformers concentrating on the individual school or district as the unit of change, a significant number of large - scale restructuring efforts have developed, some with a great deal of fanfare. Among the most notable pioneers in this field are the New American Schools Development Corporation's (NASDC) Break the Mold Schools, which funds schools with innovative approaches to education, and The Edison Project, which is using 2.5 billion dollars of provided capital to open 1000 non profit schools by the year 2010. Similar coalitions of educators and businessmen are attempting to pull together a variety of reforms and create their own version of a completely restructured school.

***Summary.*** The goals of the educational reformers discussed above are to create learning environments of personal responsibility, teamwork, high technology, community involvement, and close interpersonal relations. They attempt to involve parents, businesses and the community in a partnership to revitalize the community. Their success in accomplishing these ambitious goals is dependent upon their ability to implement change on a greater scale than on teacher by teacher, principal by principal, or district by district.

## Business

The business community has become a significant player in the nationwide drive to improve education in America. Corporate leaders have concluded that their future competitiveness is linked to the educational level of the workforce, and they have become actively involved in addressing the issue. In the words of Craig Smith, the editor of Corporate Philanthropy Report, "Now they are the most powerful, politically viable force working for social change in this country" (cited by Weisman, 1991, p11).

***Strategies.*** A variety of strategies have been adopted by business and industry to enhance the nation's educational system. The strategies are tailored by the businesses participating in partnerships to the specific problem or issue confronting them in the local community. Successful strategies include: donating or loaning resources (people and material) to the schools; establishing cooperative education programs; making facilities available for industrial purposes; furnishing technical assistance to school officials; and occasionally guaranteeing jobs, college entry, or financial aid for high school graduates (Finn, 1991).

The proper nature of Corporate America's sponsorship of educational reforms has been controversial. Robert Reich has decried business leaders' efforts to procure tax breaks from local and state property taxes, which largely fund public school systems, while simultaneously portraying themselves as advocates for school reform (Weisman, 1991). Concurrently, educators have frequently viewed businessmen solely as a cash source and have blocked initiatives that could force them to alter the educational system's basic rules and practices (Finn, 1991). From their perspective, the businessman's role should be limited to funding projects; entry into pedagogy and school issues is inappropriate. Denis Doyle has stated, therefore, that schools have been delighted to get business money, "but in personnel practices, awards for performance, incentives, disincentives - fields where business has real expertise - schools have refused to even listen" (cited by Weisman, 1991, p11).

***Programs.*** Corporate involvement in education has been evident on the macro and micro levels:

- Former Secretary of Education Lamar Alexander consulted closely with business leaders in formulating the America 2000 package.

- The Business Roundtable (BRT), representing the CEOs of 213 major corporations, has made a ten year commitment to restructuring education at the state level. The Committee for Educational Development and the National Business Alliance have joined the BRT in producing publications which outline the role business can play in restructuring and transforming the American educational system.

- Adolph Coors, Exxon, GTE, Motorola and Magnavox are just a few of the many prominent corporations that have undertaken literacy programs for company workers and, in GTE's, Magnavox's and Coors's efforts, for families of the workers as well.

Corporate leadership has supplied the impetus for many state and local education reform initiatives, and in a majority of these cases, their involvement is credited with making the difference between success and failure. Recent proactive changes in South Carolina,

Minnesota, Boston, Chicago, and Miami would not have come about without the support and involvement of key business and industry leaders. There are business/industry sponsored projects in over 30% of the nation's schools, with notable concentrations in areas of urban poverty.

A substantial portion of business's resources have been dedicated to improving the literacy and basic skills of students and workers and the quality of the school to work transition. The utility of business participation in literacy and basic skills improvement efforts in particular has many enthusiastic supporters. Donald Ford, manager of human resource development at Magnavox Electronic Systems Company, has stated that "no other area of training is as ideally suited to business-education partnerships as is literacy" (Ford, 1992, p55). Ford believes that business has the resources and captive audience to extend literacy education far beyond its traditional boundaries in public schools and libraries. Business is indeed in an ideal position to identify literacy problems on the job, develop a job-related curriculum based on the materials and skills used on the job, and then work with adult schools or community colleges to aid their employees in gaining further functional and academic literacy skills.

Corporate support of the school-to-work movement is of equally vital importance. The school-to-work movement has grown dramatically in recent years, with hundreds of active educator/employer partnerships now in place throughout the country. The Youth Apprenticeship Program, for example, features business and Department of Labor cooperation in efforts to create partnerships among youth, parents, schools, potential employers and labor organizations. Its purpose is to prepare students for careers in high demand, technical occupations, including telecommunications, aerospace, biotechnology, health care, computer assisted manufacturing, banking and finance and precision metalworking. The Job Corps also functions as a joint government and business operation and is intended to assist high school dropouts whom are economically disadvantaged, or if graduated, are in need of additional education or training to obtain and hold meaningful employment.

***Summary.*** The benefits gained from school-to-work programs can be reaped from business involvement in all aspects of education. Teachers gain access to real world learning resources and state of the art vocational and managerial expertise. Employers are given a say in what is being taught in school and gain direct access to new, more qualified employees. More students complete school and the community begins to see a reduction in social problems as school dropout rates go down and employment increases. The point made earlier in this report remains relevant, however. Business must address its expertise to educational issues, not just funding; program evaluation in such efforts as Job Corps is urgently required. Additionally, business must participate in a comprehensive nationwide reform effort: the fact that in 1990 only 10 percent of businesses had instituted training programs is disheartening.

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# INDUSTRY STUDIES

# #15

# FINANCE

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COL Richard O. Helms, USA

Mr. William J. Meehan, Jr., Department of Treasury

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CAPT Eric A. Arllen, SC, USN

Dr. Edwin R. Carlisle, Department of the Army

## PLACES VISITED

### Domestic

| | |
|---|---|
| The Federal Reserve System | Washington, D.C. |
| The Securities and Exchange Commission | Washington, D.C. |
| The Federal Reserve Bank of Richmond | Richmond, VA |
| Chicago Board of Trade | Chicago, IL |
| Chicago Mercantile Exchange | Chicago, IL |
| J.P. Morgan Securities | New York, NY |
| The Federal Reserve Bank of New York | New York, NY |
| Paine Webber, Inc. | New York, NY |
| United Nations Development Program | New York, NY |
| Goldman, Sachs & Co. | New York, NY |
| New York Stock Exchange | New York, NY |
| Institute of International Bankers | New York, NY |
| Phillip Morris Companies, Inc. | New York, NY |
| New York Clearing House Association | New York, NY |

### International

| | |
|---|---|
| Bank of England | London, U.K. |
| European Bank for Reconstruction & Development | London, U.K. |
| S.G. Warburg Group | London, U.K. |
| London Financial Times | London, U.K. |
| Bankers Trust | London, U.K. |
| American Express | London, U.K. |
| Chancellor of the Exchequer | London, U.K. |
| Royal Navy | London, U.K. |
| London International Financial Futures Exchange | London, U.K. |
| Institute Monetaire | Luxembourg, LX |
| Banque Internationale | Luxembourg, LX |
| Deutsche Bundesbank | Frankfurt, GE |
| Frankfurter Wertpapierborse | Frankfurt, GE |

## INTRODUCTION

**The Finance Industry: What Is It?**

In the time it takes to read this paragraph, someone in this country will write a check, use a credit card, get a loan, invest in a mutual fund, buy a corn futures contract, file an insurance claim, pay a toll on a public highway and make a mortgage payment. Simultaneously, similar transactions will take place around the world -- all part of the global finance industry.

The finance industry is responsible for the formation and transfer of capital. Capital, together with labor, is the fundamental element of strategic and industrial power.

The players in the American finance industry are:

**Depositors**, who place their wealth in banks and other financial institutions for a specified rate of return.

**Investors**, individuals and institutional who use their wealth to --

- buy equity in entities (normally shares of stock in a company); or
- loan money to entities (normally through bonds;

**Businesses and governments**, who raise money through sale of equity or debt;

**Intermediaries**, who bring together depositors, investors, businesses and governments; and

**the Nation**, which benefits from this interchange through lowered capital cost, increased productivity, and higher standards of living;

The finance industry includes:

**commercial banks**, which hold deposits, negotiate checks and make personal and business loans;

**investment banks**, which assist businesses in raising capital through the sale of stocks and bonds;

**insurance companies**, which invest policy premiums and offer alternatives to traditional investments;

**commercial finance companies**, which offer personal and business loans;

**commodities firms**, which trade in commodities like corn, wheat and precious metals;

**securities firms**, which facilitate investment by personal and institutional investors;

**securities and commodities exchanges**, which provide secondary markets for the trade of securities and commodities; and

**government agencies**, which regulate the activities of all these institutions.

These institutions act at various times as depositors, investors and intermediaries.

**Why Study the Finance Industry?**

> Recent events have made it clear that a world economy dominated by Cold War confrontation is giving way to one of global market competition. World leadership in such an economy will be based on economic performance. If the United States cannot compete effectively in the new global market, our relative economic strength will decline, as will our capacity for world leadership. It is thus important for our country to consider more carefully the economic and trade implications of policies adopted during the Cold War era and to determine whether they remain valid in a new age of global and economic competition. (The Senate Banking, Housing and Urban Affairs Committee)

Virtually all economic activity today takes place in the context of global economic interdependence.

> When an American buys a Pontiac Le Mans from General Motors. . .about $3,000 goes to South Korea for routine labor and assembly operations, $1,750 to Japan for advanced components. . .$750 to West Germany for styling and design engineering, $400 to Taiwan, Singapore and Japan for small components, $250 to Britain for advertising and marketing services, and about $50 to Ireland and Barbados for data processing. (Robert Reich, The Work of Nations.)

What's more, the global cash flows are not solely associated with labor and services. Transnational investments by corporations link industries and investors in a global economy. Ford owns Britain's Jaguar. General Motors owns about 40% of Japan's Izuzu, about half of South Korea's Daewoo Motors, and about half of Sweden's Saab (Reich, 1992.) Global and international mutual funds pool billions of dollars from individuals to invest in thousands of companies in dozens of countries.

This interdependence is especially significant for the United States. Our economy represents approximately 23% of the gross world product. We are the world's largest importer as well as exporter. Thus, any adjustments made to the U.S. economy will have an impact around the world, which will then be returned to us because of interdependence.

The finance industry, by creating and transferring capital in response to market

demands, is the energy source that fuels the U.S. economy. For our economy to lead the way in the face of global challenges, the finance industry must be able to meet the capital creation and transfer demands this global dimension and instantaneous pace requires. Therefore, we need to understand the basic framework of the industry, its strengths, weaknesses and challenges for the future.

This paper looks at some of the major aspects of the finance industry, both domestic and international. On the domestic side, the paper discusses:

- the Federal Reserve System
  - Responsibilities
  - Issues
- the Commercial Banking Industry
  - Functions
  - Status
  - Issues and Challenges
  - Recent Legislative Action
  - Recommendations to Strengthen

Internationally, the paper looks at:

- Export-Import Bank
  - Functions
  - Issues and Recommendations
- World Bank
  - Description
  - Issues
- International Banking Regulation

The paper concludes with some general observations on the future and recommends a number of areas for future study.

## THE DOMESTIC BANKING INDUSTRY

### The Federal Reserve System

#### *Responsibilities*

The Federal Reserve System (the Fed) is charged with:

*Regulating and supervising financial institutions.* The Fed is responsible for the

integrity of the nation's financial institutions. In carrying out this responsibility, it regulates and examines state-chartered member banks, bank holding companies, foreign branches of U.S. banks, U.S. branches of foreign banks and some corporations.

*Serving as banker and fiscal agent for the federal government.* As banker for the United States government, it processes all Treasury payments and tracks the government's balances. As fiscal agent, the Fed issues and redeems all government securities. These functions are crucial to government operating efficiency and protection of government credibility both at home and abroad.

*Supplying payment services* to the public through depository institutions. As banker for the nation's banks, the Fed provides "payment services" through either physical check sorting and routing or use of electronic systems. Electronic payments are made through the "Fedwire" system for large dollar transactions or through the automated clearinghouse service for routine, smaller dollar transactions.

*Developing and implementing monetary policy* (influencing the supply of money and credit). The Fed uses three basic tools to implement monetary policy: open market operations, the discount rate and reserve requirements.

**Open market operations** involve the expansion or contraction of the nation's money supply through the buying or selling of government securities. For example, the Fed can stimulate the economy by purchasing securities for cash, thereby making funds available for loans to businesses and other activities. It also can shrink the money supply, and therefore limit business expansion, by selling securities and taking the money paid for the securities out of circulation.

The Fed also influences economic stability through the money market, primarily through the **discount rate.** Depository institutions are able to borrow short term funds, commonly referred to as "borrowed reserves," from the Fed at the established discount rate.

Institutions can also obtain short term funds from each other, usually on an overnight basis. The Fed is active here, too, setting the rate (called the Federal Funds rate) at which these funds can be borrowed. Since the funds are not borrowed from the Fed itself, they are termed "non-borrowed funds." In both cases, the lower the rate, the more money is available, increasing activity and growth. The higher the rate, the less money available, resulting in less activity and growth.

The third basic tool of monetary policy is the setting of **reserve requirements.** Increasing reserve requirements limits a bank's lending ability. Decreasing reserves has the opposite effect. The availability of credit, interest rates and therefore, economic activity, are immediately influenced by changes in the reserve requirements.

Finally, the Fed's activities influence the international arena. The Fed's Board of Governors routinely considers the international economic climate and the impact of its decisions throughout the world. At times, the Fed plays a key role in stabilizing exchange rates through the sale or purchase of dollars. Additionally, it participates in a "swap" network in which funds are lent on a short term basis between countries. With the dramatic trend towards international banking systems, the Fed is also greatly involved in supervising

domestic activity of foreign banks. Through each of these areas, the Federal Reserve influences not only the economic well-being of this country, but exercises considerable influence over the stability of international financial systems.

***Current Fed Issues***

The Federal Reserve System has served the country well since its inception in 1913. During times of war, the Fed has ensured the nation's financial capability to fight and win. Throughout its existence, the Fed has directly contributed to the stability of prices and to a rising standard of living for Americans.

Over time, however, expectations have been placed on the Fed that go well beyond its original charter. Indeed, the Fed's initial "defensive" functions have been replaced with a much more aggressive "dynamic policy" function.

William Greider, in his book Secrets of the Temple, argues that former Fed chairman Paul Volcker stubbornly made decisions and took actions that often were in direct conflict with the Reagan administration. In fact, he credits Volcker's decision to keep interest rates high and money tight (in opposition to the President's desire for stimulus) for the financial crisis of 1987. However, others believe that his actions kept inflation in check.

Some argue that the Fed's all-encompassing economic role continued into the Bush administration and the era of the next chairman, Alan Greenspan. Rather than attributing this to a stubborn, strong-willed chairman, however, the *Economist* magazine has faulted the Bush administration itself: "The central bank's hands are tied by an administration which, by refusing to tackle the budget deficit, has dumped upon it all responsibility for economic policy."

It appears that the Clinton administration is willing to make some of the difficult fiscal policy decisions that may ultimately reduce the deficit. This should relieve some of the pressures on the Fed to solve our country's economic woes.

Currently, the Fed's independent role is coming under increased scrutiny. On March 10, 1993, the 12 Reserve Bank presidents appeared for the first time as a group before the Senate Banking Committee to answer questions regarding their responsiveness and accountability to the American people.

The Committee chairman, Senator Donald Riegle, stated that the actions of these men ". . .affect how many people have jobs, what it costs in terms of the interest rate to get a mortgage and what the rate of inflation is. But, in the normal course of events, there is very little direct public accountability."

Whether or not Congress will dramatically change the Fed remains to be seen. But the Banking Committee has made it clear that the actions of the Fed will receive closer attention in the future. The Fed's independence, though, is vital to its success. It is widely recognized around the world that the most prosperous nations have independent central banks.

## The Commercial Banking Industry

### *Banking Functions*

There are two types of banks -- commercial banks and investment banks. Both fulfill the first of the banking industry's two main functions: to provide for the efficient flow of capital and to maintain the payment system. By bringing savers and borrowers together, commercial banks provide for the efficient flow of capital by accepting deposits from individuals and businesses and loaning a portion of those deposits to borrowers for personal or business use.

The second major function of the banking system is to maintain the payment system -- the system whereby money can be safely stored and then efficiently transferred. The day-to-day operation of the national economy depends upon an accurate, efficient, on demand payment system. Commercial banks fulfill this critical function.

While this paper limits its discussion to commercial banks, it should be noted that investment banks also contribute to the efficient flow of capital. They underwrite and enable public stock offerings of companies that want to raise capital by becoming publicly owned or by increasing public ownership of their equity, and the placement of private paper and debt securities. Investment banks are particularly active and effective in attracting foreign investment into the United States.

### *U.S. Banking -- Prepared for Global Competition?*

The U.S. banking industry has faced tremendous challenges since World War II. It cannot survive without changing. Some of the challenges it now faces are:

*Banks share of deposits have fallen* as they have lost savers to mutual funds and nonbank competitors. There are approximately 12,500 commercial banks in the U.S. with a total of $3.64 trillion of assets and $2.47 trillion of deposits. These deposits represented 41% of all deposits made to financial institutions in 1989, down from 57% in 1974.

*Bank failures climbed steadily* during the 1980s -- increasing from less than 20 in 1980 to more than 200 in 1988.

*Foreign banks nearly doubled their percentage of total banking assets* from 11.9% in 1980 to 21.2% in 1990. Foreign banking institutions currently control about 25% of all U.S. banking assets, with Japanese banks alone controlling about 14%. Foreign bank loans in this country are growing three times as fast as domestic bank loans.

If ranked by dollar value of deposits, *Japanese banks hold the top ten positions*; in 1965 they had none. If ranked by assets of bank-holding companies, Japan also holds the top ten positions; the U.S. dominated the list 25 years ago with six companies.

U.S. banks have experienced a *slide in their creditworthiness rating*. In 1982, four U.S. and three foreign banks held the top AAA rating, while in 1990, only one U.S. and six foreign banks received this rating.

At one time, banks provided a major portion of the corporate world's funding. Now,

*commercial loans are being replaced by commercial paper* sold by the company through its financial operations on the world's financial market. As a result, commercial loans by banks have dropped from about $639 billion in the first quarter of 1991 to $598 billion at the end of the second quarter of 1992. The bright spot in the commercial loan market has been an increase in the loans made to small businesses.

Other loan services that banks generally provide are in the personal, automobile and mortgage areas. These areas have increased from about $1.74 trillion at the beginning of 1991 to approximately $1.9 trillion estimated for the end of 1992. Unfortunately, these *gains have been offset by increased set-asides for non-performing loans and reserves* for the "highly leveraged transaction" loans that banks made in the 1980s. Additionally, banks have made less money available for loans by "investing" the funds they do have in government securities. Government securities provide a safe investment that has almost no impact on the reserve requirements. Additionally, they provide a buffer of safe, easily convertible investments for use when demand deposits require additional cash.

An already *high overhead has continued to increase.* In a time of decreasing numbers of banks, employee population has remained fairly constant, from 1.54 million in 1987 to an estimated 1.52 million for 1992.

Since 1985, *bank profits have been disappointing* -- until recently. Although the last half of the 1980s was a rough period, there are some signs that the industry has turned the corner. Return on assets and return on equity both stopped declining in 1990 and current estimates for 1991 and 1992 are showing small improvements.

### *Banking Issues and Challenges*

After the Great Depression, we recognized the need for a sound financial system that could provide for economic growth and opportunity with emphasis on productive investment rather than speculation. To end the cycle of bank panics, banks and savings and loans received federal deposit insurance for their customers. In return, regulators attempted to reduce risky behavior to be sure that the financial system served the credit needs of the economy.

#### Bank Regulations -- the Background

U.S. law prevents the consolidation, merger or acquisition of interstate or international banking institutions. It also establishes "firewalls" between a banks and their subsidiaries and affiliates. The scope of services banks could offer was also limited. Barriers were established to protect banks and customers; yet, some are limiting competition, thus preventing economies of scale that allow services to be provided at the lowest possible cost.

The 1927 McFadden Act required banks to set up a new corporation to provide services in another state. The Glass-Steagall Act of 1933 instituted deposit insurance through an agency called the Federal Deposit Insurance Corporation (FDIC). This act tried to prevent a recurrence of dangerous lending practices that took place during the stock run-up of the 1920s.

Glass-Steagall required separation between the commercial banking industry and investment banks. This law created an artificial legal barrier between commercial banks, which take deposits and make loans to individuals and businesses, and investment banks, which help businesses raise money by selling stocks or bonds to the public. Further, the Bank Holding Company Act limited bank holding companies from offering mutual fund accounts and from selling insurance or real estate.

Contemporary policies in foreign countries are less restrictive. For example, Japan permits banks to better diversify geographically and to affiliate more broadly. The European Community will soon permit banks to expand without geographical limitations and perform greatly diversified services. EC banks may own and operate insurance companies, underwrite and distribute securities, and hold equity in other bank or non-bank companies. Ironically, U.S. banks operating in Europe may also participate in the same activities, but are prohibited from doing so when operating in the U.S.

Incomplete Deregulation

In the late 1970s, the Federal Reserve reacted to oil shock-induced inflation by radically hiking interest rates. By 1980, interest rates hit 21%. The Fed kept interest rates at high levels throughout the 1980s, even with declining inflation. At the same time, while regulations limited the amount that banks could pay depositors, the Fed ruled that money market funds could pay unlimited interest. As a result, depositors moved money out of banks into money market accounts in droves.

In 1980, Congress uncapped the interest rate banks could pay depositors. This action, coupled with the tight money policy of the Fed, led to an interest rate war as banks and their competitors bid for depositors. Congress dramatically expanded deposit insurance from $40,000 to $100,000 per account. The Reagan administration encouraged the growth of "brokered deposits." This allowed investment firms to place investor deposits in insured accounts in $100,000 lump sums. This act subverted the purpose of deposit insurance by allowing high-yield returns on taxpayer insured risk-free investments.

*Commercial Banks:* Banks faced with stiff competition for depositors from other banks and a variety of non-banks plunged into risky investments. They discarded prudent credit practices and sought high returns. Risky loans to less developed countries and unproven energy loans proved costly. Big banks also lost money on junk bonds.

The Garn-St. Germain Act aided in this investment craze by lifting the cap on the percent of loans available for investment in commercial real estate. As a result, bank portfolios of commercial real estate grew from $132 billion in 1982 to $385 billion by 1990. When the ride ended, the banks faced the cyclical real estate market crash and were unable to recover their investments.

*Parallel Banking System:* Currently, at least 60 large firms that operate money market mutual funds compete with banks. These firms invest in real estate, securities and other instruments just like banks. However, they do not have to comply with capital and reserve requirements, lending limits on loans to single borrowers, or conflict of interest rules. Lines of credit from banks support the investments of these firms, so a failure of a major finance company could ripple through the financial system bringing down any number of banks.

*Securitization:* Another major trend effecting the financial system is the rise of "securitization," the practice of bundling together loans, such as home mortgages, and selling them as securities in a secondary market. Three agencies, nicknamed "Ginnie Mae," "Fannie Mae" and "Freddie Mac," have placed competitive pressure on banks by allowing new lenders to enter the market with little capital.

Regulatory Agencies

A large number of federal and state agencies regulate the banking industry. They include:

*Federal Reserve System:* The Fed supervises nationally chartered and state-chartered banks that are members of the Federal Reserve System. The Fed also regulates bank holding companies, which own all of the nation's largest banks.

*Federal Deposit Insurance Corporation (FDIC):* The FDIC oversees the entire banking industry and directly supervises the state banks that are not members of the Federal Reserve System -- more than half of the nation's 12,500 banks.

*Office of the Comptroller of the Currency:* As part of the Treasury Department, the Comptroller oversees about 3,700 federally chartered commercial banks and about two-thirds of such banking assets -- about $2 trillion.

Bankers complain that this myriad of regulatory agencies is costly and bothersome. Yet, the recent saving and loan scandal as well as the "junk bond" saga are examples of regulation and enforcement being almost non-existent until the damage was done. The BCCI case, currently being prosecuted in New York City, adds an international dimension to a domestic issue -- foreign control over U.S. banks without the knowledge of appropriate regulators.

It is apparent that the number of personnel assigned to enforcement is insufficient and in some cases, lack the required degree of training. This is complicated by the dispersion of the enforcement function among federal and state agencies which does not allow for the proper level of coordination and intelligence sharing. The recent addition of a six person unit to the Federal Reserve recognizes this shortage but is still an inadequate response given that the depths of current problems are unknown.

Foreign Competition -- Not a Level Playing Field

Foreign banks are allowed to operate in the U.S. under any one of the following: representative offices, investment companies, subsidiaries, branches and agencies. For the purposes of this paper, only the last three will be discussed.

*Subsidiary:* A foreign bank subsidiary can be state or federally chartered, but is controlled by a foreign corporation or people. It can engage in banking, brokerage and underwriting activities. Subsidiaries must maintain a set level of reserves with the Fed. In effect, they are subject to the same restrictions as domestic banks, but also can engage in brokerage and underwriting activities, giving them a comparative advantage over U.S. banks.

Subsidiaries can be owned by a minority interest or up to 100% by parent ownership.

They are located primarily in California and New York. Japan dominates the subsidiary form of foreign banking with 34.5% of total assets.

*Agency:* Agencies account for the second largest amount of assets of foreign banks in the U.S. Generally, they are not permitted to accept domestic deposits, and until 1978, were required to be licensed in each state where operated. The International Banking Act of 1978 made it possible for agencies to obtain federally insured charters. Agencies, not subject to certain reserve requirements, instead maintain treasury bills, brokers loans and bank acceptances.

A major portion of business for foreign agencies is the commercial and industrial loan market. Much of this business is oriented around international trade between the U.S. and the parent bank organization or country. Again, as with subsidiaries, the bulk of agencies are owned by the Japanese and are predominantly located in New York and California. Liabilities are mostly short term and are directly tied to transactions originating outside the U.S.

*Branch:* A foreign bank branch is simply an extension of the foreign parent bank. Very similar in structure to an agency, foreign branches can accept domestic deposits. FDIC insurance is a requirement for federal branches and is available for state-chartered ones. The advantage of a branch is that its credit limit is calculated on the total assets of the parent bank, thus permitting the branch to solicit business from large corporate borrowers.

Similar to agencies, branches emphasize large, international trade loans. In addition, branches are able to provide current marketing and economic data and credit information through diverse international portfolios. U.S. banks see this as another distinct comparative advantage for foreign banks.

Foreign bank operations have a decided benefit for the United States. They attract large amounts of foreign investment in U.S. companies and state governments, lowering the cost of capital and fueling growth. Foreign bank operations also employ thousands of U.S. citizens and pay significant amounts of taxes.

### *Legislative Action to Level the Playing Field*

Prior to 1978, there were few laws governing the operation of foreign banks. After World War II, U.S. banks dominated the global banking scene and assisted American companies in extending their growth overseas and promoting an international export market. However, by the early 1970s, as the economies of Europe and Japan rebounded from the war, many foreign banks began to prosper in the U.S. But no U.S. policy existed to regulate them.

American banks complained that foreign banks enjoyed a distinct comparative advantage. For example, a foreign bank can establish a branch in the U.S. and solicit deposits nationwide, while the McFadden Act prohibits domestic banks from doing the same.

As a result, the *International Banking Act (IBA) of 1978* was passed to help eliminate discrimination between U.S. and foreign banks, and in some cases, established procedures that even exceeded the domestic operating privileges of our own banks. The IBA of 1978 also stipulated a national treatment approach. It was noted that the European Common

Market countries had been most receptive to reciprocal fair treatment. But by contrast, Japan has imposed numerous restrictive practices upon U.S. banks operating in Japan. Therefore, this attempt to level the playing field has been less than fully successful.

About one-half of our states prohibit the three types of foreign banks just described. A second group of states (about 15) allows banking agencies or branches, but not both. The most important states in terms of foreign banking offices are those that require reciprocity provisions. These states include California, Florida, Georgia, Illinois, Pennsylvania, Massachusetts, Texas and Washington. They use this reciprocity factor as a lever in an effort to enable their banks to gain a footing in foreign markets.

States are able to more effectively control the extent of foreign banking. As mentioned already, one way is to prohibit foreign banks from operating in the state. Another method is to limit foreign banking to agency type operations. Lastly, some states place geographic restrictions on the location of foreign offices.

The *Foreign Bank Supervision Enhancement Act (FBSEA)* was passed in 1991 to more closely supervise the operations of foreign banks. It places foreign banks under the authority of the Federal Reserve and the Comptroller of the Currency. Approval of the Federal Reserve is now required before a foreign bank can open an office in the U.S. Additionally, a foreign bank must apply to the Federal Reserve before having an equity stake of more than five percent in an American bank. Formerly, the rate was ten percent.

In our effort to level the banking playing field, we should be careful not to discourage foreign investment in the U.S. Our continued economic growth depends on our ability to continue to attract foreign investment.

***Recommended Action to Strengthen U.S. Banking***

Regulatory Relief

Bankers have made regulatory relief their number one legislative priority. Complying with excessive regulations is costing banks an estimated $7.5 billion to $17 billion each year. Bankers are currently seeking relief in the following areas:

*Restore "character lending."* This type of lending would allow bankers to make judgment calls in making loans to borrowers that might not fit regulatory criteria.

*Be flexible when applying capital standards* to evaluate a bank's health and take into account other indicators of soundness such as asset and management quality and the stability of a bank's earnings. Additionally, international capital standards are needed to ensure international banks have similar reporting procedures. In the 1980s, the rules of the Bank of International Settlements were written for this purpose. However, they need to be strengthened by omitting loopholes. New standards would serve to solve some of the accounting weaknesses that currently give the Japanese banks an apparent advantage.

*Give bankers additional rights to appeal fines* and other enforcement actions imposed by bank examiners.

*Follow existing accounting standards* and not use the authority that regulators have under current law to impose stricter accounting rules on banks.

*Ease capital rules* by giving regulators flexibility to consider other factors such as management expertise, asset quality and financial history in evaluating an institution's financial health.

*Add flexibility to bank lending decisions* by easing the formulas imposed under recent bank laws and curbing penalties for violations of these rules.

*Stop micromanaging bank operations.* Bankers argue that regulation is best done case by case and that the 1991 act requiring uniform standards does not take local conditions into account.

*Lift the paperwork burden* imposed by the Community Reinvestment Act.

Federal Deposit Insurance

Despite the recent Bank Insurance Fund rate adjustment, which penalizes banks that make risky loans, change to current federal deposit insurance is needed for U.S. banks to compete in international banking. The present disadvantage to the U.S. industry is significant since regulations require more insurance at a higher cost. The U.S. insures up to $100,000 with premiums ten times higher than in Japan, which insures up to $66,000 in deposits. Decreasing the upper limit for insured accounts from $100,000 to $40,000 would reduce insurance costs for banks and would limit potential taxpayer liability. Other developed nations limit deposit insurance for the same reasons:

- England -- 75% of deposits up to L20,000 ($15,000);
- Luxembourg -- 100% of deposits up to 500,000BF ($16,700); and
- Germany -- 100% of deposits up to DM250,000 ($16,700).

Additional methods to lower bank insurance costs include:

- Limit depositors to only one FDIC-insured account per bank;
- Pay only the insured amount in the event of bank failure, versus previous practice of paying the entire account balance;
- Change insurance premiums based on individual accounts insured versus total bank deposits.

Hidden Taxes

There are several hidden taxes including minimum capital requirements and the cost of complying with government-mandated paperwork requirements. However, the requirement to keep a certain portion of a bank's assets on deposit with the Fed is the largest hidden tax. This tax is significant because the bank does not receive interest on the money kept with the

Fed even though the Fed earns interest on these funds. In 1990, the reserve requirement "tax" on commercial banks was an estimated $3.9 billion, a substantial amount when compared with the commercial banking industry's total profits, which were about $18 billion for that year. Requiring the Fed to pay interest on all bank reserves kept on deposit could eliminate the impact of this hidden tax.

Eliminate Restrictions on Location and Services

Regulations restrict banks from branching across state lines. This regulation subjects banks to regional instability and economic downturns. Banks can overcome this restriction by using holding companies. However, the holding company must have its own corporate entity including a board of directors and separate administrative functions for each state in which a bank operates -- all of which adds to the cost of doing business.

By limiting commercial banks' ability to participate in investment banking activity, we are limiting their ability to serve their customers' needs and limiting their ability to earn profits. Some commercial banks, such as Morgan, have begun to move toward investment bank activities and have proven it can be done, and done well.

The comparative international experience of the 1920s and 1930s is particularly striking. Over 9,000 banks failed in the U.S. during the Great Depression. But in Canada, which allowed nationwide branch banking, not a single bank failure occurred.

The federal statutes that restrict services and investments prevent banks from diversifying, thereby adding to the instability of the banking system. Elimination of the McFadden Act, the Glass-Steagall Act, and the Bank Holding Company Act would introduce healthy interstate competition in commercial and investment banking. By allowing banks to diversify, the banking industry would be strengthened and exposure to failure in tough economic times would be reduced. Additionally, diversity would bring the concept of one-stop-shopping to hometown banks, providing increased and better service for customers.

Consolidate Oversight

There is a myriad of oversight agencies with overlapping jurisdiction and inadequate funding. Examinations and regulations overwhelm banks and S&Ls. Moveover, the industry's interest groups dominate the agencies that are responsible for their regulation. Combining the resources and oversight of federal agencies into one streamlined, adequately funded, independent agency makes sense. This would require the establishment of a clearing house for information and intelligence, along with the ability to coordinate the efforts of the agencies involved. This would also free banks from having to answer to different -- and sometimes conflicting -- examination procedures and requirements.

Additionally, numerous banking professionals have asserted that self regulation is sufficient. While this might not "square" with the events of the recent past, it is clear that there is a major role for self regulation by the professionals in the industry. The government could facilitate such self regulation by providing a methodology for banking professionals to provide information on activities that appear to be illegal or questionable. The future trust of both the banking industry as well as the veracity of the enforcement agencies requires a new level of cooperation in order to ensure the financial security of the U.S. banking and securities

industry.

National Treatment Must Be Negotiated

National treatment offers equal opportunities to all banking institutions in any market and makes them subject to the same restrictions as other institutions in that market regardless of origin. Under a national agreement, Japanese banks in America would function like American banks; similarly, American banks in Japan would act like Japanese banks. An alternative is to sign reciprocal agreements permitting limited numbers of banks or services into a market. Adequate standards must be established that allow U.S. banks equal opportunity to operate in foreign countries. An example of a successful reciprocal situation is the U.S. - EC relationship, where U.S. banks have done well.

Raise the National Savings Rate

During the 1980s, the national savings rate fell from its 1959-1980 average of 8.2% of national income to 3.0% in 1990. This resulted in a competitive disadvantage for all U.S. financial institutions. Reduced savings led to higher real interest rates, which raised the cost of capital and therefore lowered investment. The national savings rate needs to be restored to 7 - 8% of national income.

The most important action that can be taken to restore the national savings rate is *reduction of the federal deficit.* If deficit spending could be reduced to zero, then the national savings rate could theoretically jump to about 6.6% of national income.

Additional actions for consideration include those listed below. These actions are primarily the responsibility of government. The role of the financial services industry is to advise government in developing legislation and to comply with the letter and spirit of these efforts while meeting its fiduciary duties to its clients.

- Restructure tax laws to encourage saving
- Reevaluate social insurance programs which are a disincentive to save
- Aggressively encourage appropriate retirement savings plans such as defined contribution plans
- Provide public education regarding the individual and societal benefits of savings
- Curtail marketing of personal credit such as marketing credit cards to minors

## INTERNATIONAL FINANCING ORGANIZATIONS

International financing encompasses a broad range of private, governmental and intergovernmental organizations. We've previously discussed the role of our Federal Reserve and our U.S. commercial banking firms, both of which actively participate in international financing operations by facilitating currency transactions and financing international trade and monetary transactions. However, private financing is sometimes either unwilling or unable to finance international trade and development activities in areas where there are unacceptably high levels of commercial and/or political risks. Also, the scope of the financing might be too great for any commercial organization to assume the large risk. To facilitate such situations, government and intergovernment financing organizations help provide the scope and coverage for these risks by making direct loans, guaranteeing private loans or providing loan insurance. In this section, we will discuss the Export-Import Bank and the major multinational organization, the World Bank.

### U.S. Government International Financing

The U.S. Government uses international financing and assistance to advance our strategic economic interests around the world. Prominent programs include the U.S. Agency for International Development (AID), the Export-Import Bank (Eximbank), the Commodity Credit Corporation (CCC), the Overseas Private Investment Corporation (OPIC) and the Trade and Development Agency (TDA). Each one of these agencies supports a particular national policy and contributes to our overall economic national strategy. This discussion will focus on the Eximbank, given its significant role in supporting U.S. industry's efforts to achieve greater economic competitiveness.

#### *Export-Import Bank (Eximbank)*

Unlike most of the other U.S.-sponsored financing and assistance programs, Eximbank focuses on assistance to U.S. exporters as opposed to assisting developing countries. It is the single most important financing institution supporting U.S. capital goods and services exports. As exports become more vital to our economic future, and as domestic demand is growing slowly if not stagnating, export financing becomes even more critical to our economic competitiveness. Strong exports are as important to our strategic global position as is our strong military capability.

For the most part, the U.S. is a proponent of free trade. Industries should compete in the market solely on the basis of real market factors such as products, prices, services, marketing and delivery. However, another important part of trade competition is the financing portion. Without the availability of credit, on competitive terms, U.S. businesses could be excluded from potentially lucrative overseas markets -- markets that can provide new jobs for Americans. Eximbank provides essential financing support by helping U.S. exporters and foreign buyers of U.S. goods and services obtain the financing required to complete the sale.

Eximbank supported over $25.5 billion in export activity in the last two fiscal years with another $15.5 billion estimated for 1993. An example of Eximbank's ability to assist with export opportunities is its recent support of a sale of five McDonnell-Douglas MD-11 aircraft to China. Additionally, by pioneering the bundling of export financing for a country as well as the bundling of trade receivables, Eximbank has begun to attract U.S. banks back into trade financing, especially for small and medium importers in Latin America.

Eximbank aids U.S. exporters through three basic programs: direct loans, loan guarantees, and insurance coverage, all at generally close to market credit terms. The two primary reasons for Eximbank involvement are unavailability of commercial financing and concessionary trade financing by other exporting countries. A short explanation of each follows.

*Commercial financing is unavailable.* In a lot of developing countries, financial capital is just not available to finance that country's imports. Additionally, their banking systems might not have evolved to the level of sophistication where they can provide loans for complicated business transactions. Normally, if a certain country's financial systems are not capable of providing loans, U.S. private financial institutions should be able to step in and provide this service. However, there is an increasing reluctance to provide loans to Less Developed Countries (LDCs) because U.S. banks lost substantial amounts of money in the recent Third World debt crisis.

If the political and/or commercial risks are such that private banking will not get involved, Eximbank can step in and provide the export financing support. Eximbank's programs provide protection against non-payment for:

- Political Risks: (war, cancellation of export or import licenses, expropriation, confiscation or interference by the host government, and foreign currency transfer risk), or
- Commercial Risks: (deterioration of buyer markets, unanticipated competition, buyer insolvency, and natural disasters).

*Concessionary trade financing is involved.* Eximbank is only one of many Export Credit Agencies (ECA) throughout the world. Most of the major developed countries also provide export credit to their exporting industries that is frequently in direct competition with our own. This competition is a normal part of doing business, as long as the credit activity is based on market conditions. However, some of our trade competitors offer subsidized financing and/or "tied" aid credits, whereby the donor country subsidizes the cost of the transaction to the buyer in return for the purchase of its goods. These types of actions subvert free market principles and put our exporters at a distinct disadvantage. If protests by our government through the U.S. Trade Representative, or State or Commerce Departments don't remedy the situation, then Eximbank is authorized to offer its own subsidized financing or use its "war chest" of Congressionally appropriated tied aid credits. These actions either stop the use of the other country's concessionary credits or level the playing field to allow our exporters to compete fairly. Since tied aid is recognized as a trade-distorting practice, as well as being expensive, the U.S. has pushed for agreements that limit or end this practice.

## Problems and Issues of Eximbank

Eximbank is not without criticism. Industry claims that Eximbank's bureaucratic slowness affects the responsiveness of its support. It is dependent on obtaining the guarantees of its loans by the governments of importers, which has created difficulty in Eximbank making the transition to the rapidly evolving world of privatization of power, telecommunications, and other industrial sectors -- especially in emerging markets and recently democratized countries.

## Recommendations to Strengthen the Eximbank.

- Review national policy with a view toward establishing a special augmentation to Eximbank's budget authority to aggressively support exports to the newly emerging democracies in Eastern Europe and the Former Soviet Union. This could assist with building the economic infrastructure of those countries while giving our businesses the sound groundwork for long-term relationships in a major new marketplace.

- Review policies regarding Eximbank foreign content support with a view towards relaxing those restrictions. Foreign content rules (which preclude Eximbank financing for non-U.S. part of an export) are intended to preserve American jobs. However, with products becoming more and more global, in the long-run, this restriction could actually damage our overseas competitiveness, resulting in lost sales and a respective loss of American jobs. A sale, even if it has only a majority of U.S. inputs, is better than no sale at all.

- Establish budgetary mechanisms to sufficiently respond to Eximbank funding requirements as the demand for export credits grow. This includes a relook at how the cost of Eximbank's financing programs are accounted for under the new budget authority (a part of the Federal Credit Reform Act of 1991) in order to remove any bias for direct loan programs over their guarantee programs.

- Eximbank should continue with its efforts to become more decentralized. By getting their programs out to all areas of the country, they can greatly enhance business awareness of their programs and involve local banks that can reach out and assist new potential exporters. Additionally, Congress and the administration should review policies that restrict and make Eximbank programs less effective. A change in mindset is required! Eximbank's programs should be looked upon as a tool to assist our exporters in competing in the new global marketplace.

## Closing Thoughts Concerning Eximbank

The above recommendations are a way of suggesting less restrictions and a greater involvement by Eximbank in supporting our export economy. Government financing agencies like Eximbank can be in the forefront of a new government/industry partnership that provides our nation with the capability to compete successfully in the new global marketplace.

**Multilateral International Financing**

Among the intergovernmental development banks started in the wake of World War II, none has the size, worldwide reach, impact and reputation of the World Bank. The World Bank coordinates closely with United Nations activities, the International Monetary Fund, regional development banks, national development banks and a plethora of autonomous nongovernmental organizations (NGOs) from all over the world. It is an important player in the evolution of worldwide trade, finance, resource development, societal evolution and the environment. With assets of over $140 billion and 61 offices around the globe, the 6,046 member staff of the bank has dedicated the last two generations to massive economic improvements for many of the poorest, least developed nations. Now faced with the breakup of the Soviet Union and a free Eastern Europe, and by an undiminished gap between the richest and poorest countries, the World Bank has formidable challenges facing it in the remainder of this decade.

***Origins***

The World Bank owes its birth to the Bretton Woods Conference, more formally known as the United Nations Monetary and Financial Conference, held in New Hampshire, July 1-22, 1944. Despite its origins in one of the many meetings planning the post-war world, the 44 governments represented designed an entity independent from the United Nations. Their intention was to design an organization capable of making long-term capital available to needy countries. Simultaneously, they designed the International Monetary Fund (IMF), primarily to keep international exchange rates stabilized. These organizations were among the most important manifestations of a growing maturity and awareness of the United States' role in post-war reconstruction. Although the United States pursued much of its own independent foreign aid programs in the years that followed the war, especially the $17 billion Marshall Plan, the terms of interaction gave the other participants in the World Bank a sense of power and responsibility, despite the major role of the U.S. government. It also effectively isolated recipients from claims of playing to U.S. imperialism in borrowing Bank funds. After some initial loans in reconstructing Europe, the Bank turned its attention to the so-called developing countries. Since then, the Bank has loaned over $210 billion to some of the world's poorest nations.

World Bank Organizations

The World Bank consists of four principal organizations. A brief description of each follows.

*International Bank for Reconstruction and Development.* The IBRD lends for productive purposes that stimulate economic growth. It looks for good prospects of repayment and only makes the loans to member governments or enterprises, for which the guarantee is made by the sponsoring government. Loans are generally repayable in 15-20 years, with five-year grace periods. Although early emphasis was in large projects such as roads, dams, power plants, education and agriculture, recent world changes have required loans to help in

making economic structure changes and in solving balance-of-payments problems. The Bank sees itself making appropriate changes in its thinking to reflect the world situation. In the 1990s, the Bank expects to help achieve sustainable economic growth, reduce poverty and concurrently protect the environment.

*International Development Association (IDA).* Fourteen years younger than the IBRD, the IDA has similar purposes as its older model but concentrates on poorer developing countries, those with an annual per capita gross national product of less than about $600 (1990 US dollars). In general, borrowers can expect more favorable terms than from the IBRD. IDA loans could have terms as long as 40 years and usually with no interest. However, the terms keep the World Bank requirement for a government guarantee. While membership in the IDA is open to all the members of the IBRD, only 142 members had joined as of June 30, 1992.

IDA funds come from subscriptions of the more industrialized and developed members, and loaned in contracts commonly called "credits." Additional funds are sometimes made available from IBRD transfers from net earnings. The loans are traditionally made only to governments.

*International Finance Corporation (IFC).* The purpose of the IFC is to finance various projects in the private sector through loans and equity participation. Established in 1956, the IFC had 146 member countries as of June 30, 1992, and all must also be members of the IBRD. The IFC doesn't require the usual government guarantee and concentrates on the economic development of less-developed countries. But the IFC does look for manufacturing firms that have a reasonable chance of earning the investors' required rate of return and that will provide economic benefits to the nation. The policy that sets the IFC apart from most development banks is the fact that it does not stipulate where the proceeds of the loans are spent. The IFC has in the past supported tourism, animal feed, publishing, iron and steel, fe. .ilizers and textiles.

*Multilateral Investment Guarantee Agency (MIGA).* This newest member of the World Bank Group dates from only 1988. As of June 30, 1992, 85 countries were members. It has a special purpose to encourage equity investment and other direct investment flows to developing countries through the mitigation of noncommercial investment barriers. MIGA offers member governments advice on foreign investments and sponsoring dialogue between international businessmen and host governments.

Financial Operations

The Bank operates primarily by borrowing on world markets and then making loans to developing countries at favorable rates with excellent conditions. At the end of fiscal year 1992 total borrowings were $97,056 billion, an 8% increase over 1991, all of it in medium- to long-term agreements. The Bank further attempts to reduce borrowing costs by entering into complex currency swaps, forward exchange agreements and interest rate swaps. These maneuvers resulted in $483 million in reduced interest expenses in 1992. The Bank also seems to be aggressively taking advantage of falling U.S. interest rates.

The operation in which the Bank meets its charter is the placing of loans. The 1992 balance sheet shows approximately $154,933 billion in total loans. However, this figure is adjusted by 35% either as loans approved but not effective or as an undisbursed balance on existing loans. This means at the end of the fiscal year, the Bank had only $100,810 billion loaned, or in other words, 72% of the statement total assets. As the uncalled capital subscription of $142,188 billion is not totaled in Bank equity, the actual level of the Bank's total loans (including the undisbursed portion) is only 55% of the real and potential assets. At the end of fiscal year 1992, the Bank (just the IBRD) had loans placed with 90 members plus three smaller development banks.

World Bank Concerns and Issues

*Reducing Poverty.* The World Bank is in the business of reducing poverty. The Bank has a two-part strategy calling for labor intensive economic growth and social services. But the goals against which these strategies were to have been applied have changed and the reduction in poverty, seen as possible in 1990, no longer seems attainable in 1992. Nonetheless, the Bank has put the recession behind them as well as their record of the 1980s, and with high hopes looks to the next century for marked change.

In attaining their new poverty goals, the Bank has defined two key elements:

- Formulation of country-specific poverty assessments that establish whether specific government policies, public expenditures and institutions are consistent with the goal of reducing poverty and recommend necessary changes; and
- Design of country-specific strategies that ensure that the Bank's programs support and complement countries' own efforts to reduce poverty.

Research is also a key function at the World Bank and absolutely essential to the elements above. But it is in the country-specific strategy that we can see the Bank principles at work. It is Bank policy to tie lending volume largely, but not exclusively, to a country's efforts to reduce poverty, and (how) the sectoral and intersectoral composition of Bank lending will support efforts to reduce poverty.

The above plan sounds good, but only about 25% of the assessments are complete. Where assessments have not been completed, the Bank's traditional economic and sector reports are often used to influence the design of assistance strategies.

*Making Improvements.* The Bank does listen to criticism and makes adjustments to their programs. Improvements include information gathering and systems to process this data. Encouraging local participation and the cooperation of nongovernmental organizations (NGOs) is essential in many new projects.

*Human Resource Development.* This is a growing area of concern in the Bank and increasing resources have been applied. Education, and the Population, Health and Nutrition

sectors appear to be of increasing concern. Overall the Bank is changing lending objectives from physical infrastructure to sector and policy based strategies.

*The Environment.* It is certain that the World Bank of today is more sensitive to environmental issues than at any time in its history. At least in its verbiage, the Bank links development and the environment. But words alone will not reverse the damage done by some of the Bank's past projects, many of which continue.

The Bank did take part in the United Nations Conference on Environment and Development in June 1992. Of 222 projects approved in 1992, 19 had primarily environmental objectives with a net lending total of $1.2 billion. The interested reader can find greater detail on these and 43 other projects that had environmental components at least as part of the project.

Environmental critics of the Bank are among the most vocal. They criticize not only the projects themselves but the Bank's policies, which in their view have led to widespread damage to the planet. Here also, the Bank is reaching out to NGOs, seeking cooperation, recommendations and accommodation. The Bank in cooperation with the United Nations is the home for the relatively new Global Environment Facility. It now houses the Ozone Layer Protection Trust Fund and the Global Environment Trust Fund. Other trust funds are likely to be added in the future. Various NGOs seek Bank policy changes that will support energy efficiency, biodiversity, cessation of ozone depletion, etc. More sophisticated critics have even attacked the very premise of the sort of policy based lending leading to structural adjustments in various national economies, that the Bank to a large extent has supported.

Closing Thoughts on the World Bank

An outsider looking at the World Bank would naturally be concerned about the size, cost, function and policies of the World Bank. However, it appears to be an organization that was well organized, efficiently run (certainly as compared with some other organizations that share their birthright in the United Nations discussions of the 40s), and pursuing a vision for the future. The World Bank may be one of the most successful examples of international cooperation in history.

**International Banking Regulation**

International enforcement of international banking is currently insufficient to both discover and prevent another BCCI-type scandal. Bank of England officials pointed to the lack of regulatory capability of Luxembourg when discussing BCCI. The Luxembourg officials indicate that an institution the size of the Bank of England should have had the resources to monitor the activities of BCCI in the United Kingdom. Various changes have been instituted in the wake of BCCI. However, these are not unlike the changes made in the U.S. -- too little to truly make a difference. Again using BCCI as an example, there were rumors and reports generated about the banking practices of BCCI, but nothing substantive was accomplished until British intelligence became interested in some of BCCI's clients. However, this interest came too late to prevent the loss of millions of pounds to various UK firms and citizens.

Not unlike the U.S. banking environment, the global system requires a "clearing house" or INTERPOL type of institution in order to facilitate information and intelligence exchanges. This facility could be supported by the central banks and through national membership. Banking and investment personnel would be encouraged to report suspicions and knowledge of illegal transactions to this central facility. Given the civil and criminal liabilities that banks and bankers face for involvement in illegal activity, known or unknown, it would seem prudent for bankers to protect themselves by being able to report and therefore self police. The international nature of such a facility would allow its members to act upon information and alleviate the current jurisdictional restrictions that now encumber international regulation and enforcement.

The movement of capital around the globe on a 24-hour basis in such volume that currently exists completely dwarfs regulators' efforts and reduces the process to very selective examination. Truly, self regulation and effective international enforcement is the only current safeguard against criminal activity. However, more needs to be done. As Peter Drucker observes in The New Realities, "the transnational world economy is reality, it still lacks the institution it needs. Above all, it needs transnational law." Banking and finance are the underpinnings of the transnational economy -- transnational law, regulation and enforcement are required.

## AREAS FOR FURTHER STUDY

### Automation in Securities Exchanges

The securities and commodity exchanges are key players in the finance industry. Their roles in raising capital and managing risk can hardly be overstated.

Some exchanges have embraced automation not only to cope with the volume of activity, but also to augment their trading capability. For instance, the Chicago Board of Trade and the Chicago Mercantile Exchange use GLOBEX to trade issues not traded on the floors. The London International Financial Futures Exchange uses an automated system to extend its trading hours by two hours per day. And the Frankfurt Stock Exchange uses automation to both enhance floor trading and extend its trading hours.

Notably, other exchanges have shown considerable reluctance to use automation to do much more than process action completed on the floor of the exchange. The Chicago Board of Trade, the Mercantile Exchange, and The New York Stock Exchange all have a negative attitude toward automated trading. The predominant feeling of opponents to automated trading is that it is less effective than floor trading at discovering price. They maintain that such things as nuances of trader body language, pit activity and sensing of trader attitudes help traders discover price more effectively than can be done through machine (computer) interface between buyers and sellers.

**Derivatives**

During the 1980s, investment banks expanded their traditional role of marketing stock offerings to include managing risk for their clients. These "off balance sheet" activities involve operations in a broad category of investments called derivatives. Other types of large firms (i.e., Phillip Morris), have also embraced derivatives.

Derivatives are created by repackaging basic financial investments into units that more closely resemble the clients' needs or provide a hedge against adverse financial developments. These types of investments are often extremely complex and involve huge sums of money. Use of derivatives has proven extremely effective at managing market risk and very profitable for some participants. However, they appear to be unregulated and well understood by only a relatively small group of people.

**Insurance Companies and Pension Funds**

These entities have long been powerful investors. Issues associated with their role in the financial services industry include:

- their influence as "active" shareholders in various corporations and sectors of the U.S. economy,
- their influence as long-term or short-term investors, and
- their impact on the commercial banking industry (since they provide an alternate means of individual savings).

**The Role of Financial Services In Economic Development**

The National Security Strategy of the United States recognizes that economic development in the former Soviet Union as well as other lesser developed areas is in the best interest of the U.S. An efficient, effective and complete financial services sector is a prerequisite to advanced economic development.

What actions (both government and commercial) might be appropriate in assisting development of their financial services sectors?

Likewise, further economic integration in the EC may be stymied for a number of reasons. How significantly will this lack of progress impact U.S.-based financial service firms (and other firms) operating in the EC?

### Developing New Markets in High Growth Areas

Asia and Latin America are enjoying dynamic economic growth. They are expanding their imports of U.S. goods and services much more quickly than Europe or Japan. Neither U.S. banks nor corporations seem to be maximizing the high yielding trade and investment opportunities that are presented. We should identify ways to increase the involvement of the U.S. financial services industry in these emerging markets.

## CONCLUSION

All together, the Finance Industry Study Seminar visited more than a dozen firms in the U.S. and Europe and heard from a number of speakers about various aspects of the finance industry. This paper has only scratched the surface of the industry, its complexity, and its problems and challenges. However, we have come to some conclusions concerning the industry and its future.

### The Federal Reserve System

The Fed is the bedrock of American finance. Its measured, nonpartisan approach to this country's monetary needs is the root of the success this country has enjoyed this century. We need to protect and promote the Fed's independence. The fact that other countries, such as France, look to the Fed as a model of how a central bank should operate, is eloquent testimony for preserving a system that has served us well.

### The Domestic Banking Industry

The U.S. banking industry must change if it is going to survive. The industry performs a vital role in operating the payment systems and in the formulation and transfer of capital. It must find ways of meeting competition domestically from nonbank institutions, and globally from foreign banks. We have the people. We need the will.

### Automated Markets

The equity and commodities markets in the U.S. must redouble their efforts to find the best way to automate trading. We believe that the automated trading we saw in places like Frankfurt are the future. Unless our markets do more to integrate automation into the trading process, they will be left behind.

### The European Community

The EC will increase in importance in the global economic scene, but it is far from being the economic steamroller that some have predicted it will be. It is a long way from any integrated currency, and its vaunted currency mechanism is still in tatters after the run on selected European currencies last fall.

**The Former Soviet Union and Eastern Europe**

Eastern Europe has begun its climb out of the dark years of communism, and several countries, particularly Poland, are on the cusp of success. The former Soviet Union, however, has a very long way to go before it will have anything approaching a western style market economy. The Russians are trying to move from a command to a demand economy, but they lack the process infrastructure needed to make a demand economy work. Until they can create a stable political structure and a hard currency that is freely convertible, they will have a rough time of it.

**International Currency Regime**

National governments no longer can control their currencies. The global financial market is to vast and too fast for any one country to exert any sort of meaningful control. Therefore an international agreement concerning the regulation of money flow is needed to combat fraud and money laundering worldwide. An international enforcement agency needs to be part of this operation, with sufficient funding and power to control and prevent abuse of this vital world market.

Finance is the engine that runs the world's industry. It is vital to our national security that we understand its functions, its problems, and its challenges for the future.

# Industry Studies

# #16

# Advanced Materials

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## PARTICIPANTS

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## PLACES VISITED

### Domestic

| | |
|---|---|
| U.S. Bureau of Mines | Washington, D.C. |
| Advanced Research Project Agency (ARPA) | Arlington, VA |
| Americon Iron and Steel Institute | Washington, D.C. |
| Sparrows Point Plant, Bethlehem Steel Corp | Baltimore, MD |
| National Critical Materials Council | Washington, D.C. |
| Business Communications Co., Inc. | Norwalk, CT |
| Applied Physics Laboratory, Johns Hopkins University | Laurel, MD |
| U.S. Department of Commerce | Washington, D.C. |
| Wright Aeronautical Laboratory, Materials Directorate | WPAFB, OH |
| Center for Composite Materials | University of Delaware |
| W.R. Grace & Co. | Columbia, MD |

### Canada

| | |
|---|---|
| American Consulate | Montreal, Quebec |
| ALCAN Research and Development Center | Kingston, Ontario |
| Bombardier Aerospace Group | North America, Montreal |
| FRE Composites, Inc. | Longueuil, Quebec |
| Herous, Inc. | Longueuil, Quebec |
| Hydro-Quebec | Montreal, Quebec |
| Industrial Materials Institute | Boucherville, Quebec |
| Industry, Science and Technology Canada | Ottawa, Ontario |
| National Research Council of Canada | Ottawa, Ontario |
| National Defense College of Canada | Kingston |
| National Defense Headquarters, Defense Industrial Resources | Ottawa |
| Chief of R&D, Dept of National Defense | Ottawa |
| Pratt & Whitney, Canada, Longueuil | Quebec |
| SIDBEC-DOSCO, Inc., Contrecoeur | Quebec |

### Japan

| | |
|---|---|
| Kyocera Corporation | Kyoto |
| Murata Manufacturing | Kyoto/Nara |
| Japanese Middle Army Headquarters | Kyoto/Nara |
| Kawasaki, Heavy Industries Shipyard | Kobe |
| Kobe Steel Company | Kakogowa |
| NGK Insulators, Inc., (Fine Ceramics) | Nagoya |
| Mitsubishi Heavy Industries (Komaki Minami Works) | Nagoya |
| Mitsubishi Heavy Industries (Nagoya Systems Works) | Nagoya |
| U.S. Embassy | Tokyo |
| Japanese Defense Agency | Tokyo |
| Toray Research Laboratory | Tokyo |
| Ministry of International Trade and Industry | Tokyo |
| Fujitsu, Atsugi Research Laboratories | Tokyo |
| Mitsubishi Heavy Industries (Sagamihara Works) | Sagamihara |
| Japan Industrial Bank | |

## INTRODUCTION

Advanced materials make a critical difference: their unique high performance characteristics enable our high-tech weaponry to push the edge of the technological envelope, giving us an increasingly critical technological edge. And they strengthen our economy, affording us the potential to achieve and maintain an equal advantage in the marketplace.

But there is no such thing as a free lunch, and advanced materials carry with them a two-edged price tag: pushing the edge of the technological envelope, they require substantial research and development funds, and then engender extraordinary costs for production and manufacture.

And for all of their promise, advanced materials pose special risks as they push the limits of the laws of nature. The risk of catastrophic failure is always present at the edge of the envelope, and while defense applications must sometimes accept that risk, civilian industry is reluctant to sacrifice the reliability demonstrated through long experience that leads to product acceptance in the marketplace.

Because the advanced materials industry is too often transparent to strategic planners, hidden as it is below the second tier of defense contractors, Industry Studies Committee on Advanced Materials undertook to shed some analytic light on the problems and the potentials of that industry, with the hope that strategic planners will better appreciate both those problems and the potentials advanced materials present in the context of both our defense needs and the larger issues facing our national economy. This report summarizes the results of a five-month study that included field research in Canada and Japan.

Like beauty, the classification of an advanced material is often defined by the perspective of the user: what is advanced in one segment of our society may already be routine in another. For the purpose of this study, however, we would describe advanced materials as materials (l) developed since 1960, (2) designed to have specific properties, and (3)tailored for small specialty markets where there is a requirement for exceptional performance.

Implied in that description are three other critical features of advanced materials: (l) their production depends upon the latest technologies (2) they are synthetic and highly processed, with a high value-to-weight ratio and high value added, and (3) their development is focused and relatively rapid.

Advanced materials can be divided into three major groups:

- Polymers and polymer composites
- Metal alloys, superalloys and metal matrix composites
- Ceramics, ceramic composites, and ceramic coatings

In this, the first year of a proposed three year study of the advanced materials industry, the Committee focused on the ceramics industry: as the newest, the most promising, and

most problematic of the advanced materials industries, it would best serve to define the challenges facing the industry as a whole and thus would constitute a baseline for future work.

The advanced ceramics industry is frequently referred to by other names, depending on the region or country of origin - advanced ceramics can also be called industrial ceramics, engineered ceramics, fine ceramics or enhanced ceramics. Regardless of the name, the advanced ceramics industry is comprised of firms involved in the process of developing non-ferrous based products for a wide field of applications. These structural materials, called "advanced" because they have to be designed to have the properties required by a given application, offer superior properties to the more traditional metals (e.g., steel, aluminum, and nickel) or metal alloys (e.g., ferromanganese).

The advanced ceramics industry becomes even more broadly defined when considering composite ceramics (or CMCs) - advanced ceramics formulas that are reinforced by various compositions of fibers, whiskers or particles. For the purpose of this paper, the CMC industry will be included as part of the advanced ceramics industry.

Although the properties of advanced ceramic products vary by design, they generally are, when compared to most other materials, of higher temperature strength, greater friction wear resistance, greater chemical resistance, lower thermal conductivity, and lower thermal expansion than conventional products.

The importance of these properties to both the commercial and governmental sectors of the economy are evidenced by the advanced ceramics and materials industry being identified as a National Critical Technology, Commerce Emerging Technology, and Defense Critical Technology.[1]

There is no one specific SIC code for the industry, because the codes are assigned to types of end products, not processes. A review was made of twenty firms that are members of the US Advanced Ceramics Association, a Washington D.C.-based trade association. These firms, though only a small percentage of the total industry, had products classified in over sixty SIC codes.[2]

Advanced ceramic applications can be divided into five broad categories: structural ceramics, electrical ceramics, capacitors/substrates/packages, ceramic coatings, and optical fibers. In the commercial sector, products include wear parts, cutting tools, bearings, bio-ceramics (ranging from artificial joints to dentures), electro-chemical devices, heat transfer parts, ceramic filters, fiber optics, and sporting goods.

Products for the governmental sector include most of the commercial applications, plus gun liners, ceramic armor, various missile and modern ammunition parts, and space shuttle cones and tiles.

Ceramic powders of specific, ultrapure composition are necessary ingredients for most advanced ceramics. Thus the production of ultrapure and uniform ceramic powders is an integral part of the industry, and represents an additional set of technological challenges and economic potentials: as new powder production processes are developed and integrated into the manufacturing process, they can have a significant impact on the cost of the finished

ceramics, making them more competitive with traditional materials.

**Structure of the Industry**

There are many different types of firms involved in advanced ceramic research or production or both. They may be traditional ceramic manufacturers or systems manufacturers that are end users of advanced ceramics structures; they may produce only one type of advanced ceramic product or they may be large diversified manufacturers.

In the U.S., however, most are not horizontally integrated to any great degree, concentrating their efforts on at most a few application areas and material types. Their vertical integration varies with application: in some structural or engineering applications--e.g., wear parts and heat engine components--the same companies producing the ceramic powders have moved downstream into manufacturing, while electronics ceramics firms still depend upon powders produced by companies that make traditional commodity ceramics such as abrasives and refractories.

The U.S. advanced ceramics industry can be characterized as one of little growth of new firms; increasing reliance on mergers and partnerships; increasing multinational scope; and an increasing dedication to the commercial application of its products, with a cautious optimism for the future.

Several ceramic production firms have evolved from firms that originally specialized in ceramics technology research and development; but they have tended to be focused in only a small range of applications. There have also been instances of ceramic product users expanding upstream to ceramic production- the most noticeable addition being IBM.[3]

Entry of new firms is extremely cost prohibitive, especially in today's international competitive environment. The creation of new American firms, specializing in only one major product line (e.g. electronic ceramics) could easily cost in the hundreds of millions of dollars. One source estimates the capital cost of a U.S. advanced materials firm at $92,000 per employee, compared to an international average of $42,000 per employee. Although not discussed, this dispersion may include a combination of factors to include a higher cost of machinery and a more productive ratio of machinery to employee.[4] In addition to the high start-up costs, there are significant costs in qualifying a ceramics process. The Semiconductor Industry Association estimates a semiconductor company must invest an average of between $50,000 to $75,000 to qualify a new ceramic package supplier for just one package - and most semiconductor firms require a multitude of packages.[5] Qualification entails an extensive and clostly testing and evaluation process.

Labor costs, while not a primary inhibitor to the start-up of new firms, does play a role in maintaining a competitive edge in the international industry. The U.S. advanced ceramics industry is a mix of union and nonunion shops where labor costs can often exceed $15.00 per hour. Japanese labor costs average under $10.00 per hour, while the labor costs in the non-industrialized nations are much lower.[6]

Independent analysts predict that the U.S. market for advanced structural ceramic components will experience an average annual growth rate of 13.0% over the next 7 years,

rising from $385 million to $1,020 million by the year 2000. Ceramic coatings are expected to demonstrate an average growth rate of 9.8%, rising from $445 million to $940 million in the same period. Finally electronic ceramics, the dominant form of ceramics in the current market, will retain their predominance, but will achieve only an 8.5% annual average growth rate, rising from $3,370 million to $6,490 million during the same period. These projected growth rates exceed that projected for the U.S. economy by a factor of 3-5.

The Department of Commerce's Bureau of Export Administration reports that DOD is not, by volume, a major consumer of such domestically produced advanced materials, requiring only about an average of 4% of domestic production. But those materials are critical to most weapons systems, housing as they do the most advanced electronic components in those systems.

That criticality is at the core of a structural problem underlying Coors Electronic Package Company's petition for relief under Section 232 of the Trade Expansion Act of 1962. According to documents filed in support of that petition, Coor contends that U.S. defense interests are challenged by the dominance of a Japanese firm, Kyocera Corporation, in the electronic ceramics market.

Kyocera America, Inc. is the wholly-owned subsidiary of Kyocera International, located in San Diego California, which is, in turn a wholly-owned subsidiary of Kyocera Corporation of Japan. Kyocera America sells to commercial concerns that use ceramic packages for both civilian and military applications. Kyocera America fills U.S. government orders from its Japan-based parent company, its Mexican maquiladora facility, and from its European operations.

According to the Department of Commerce, Kyocera actually supplied from its American facility only about 5.5% of the products it shipped to the United States government for the weapons systems studied[7]. Kyocera currently has approximately a 75% of the world and U.S. market in electronic packages and a 95-98% share of the U.S. defense market.

This petition is still working its way through the legal process, but both its substance and its ultimate resolution will warrant further attention by policy makers. Its significance is heightened by another trend in the industry: from 1988 to 1991, 36 U.S. advanced materials companies were purchased by foreign firms, 28 of them by the Japanese.[8]

The Committee believes that, in the event of a national reconstitution effort, advanced ceramics producers will have the capacity to respond to a surge in requirements: the industry is characterized by small-lot, quick-response production of a wide range of fully-developed products. Further, given their role as sub-tier suppliers, they will have more than sufficient lead-time to initiate production. And while many are concerned about the impact of Japan's dominance in the field and that nation's constitutional and historical commitment to non-belligerence, fearing that the flow of critical products needed in pursuit of our national military objectives will be constrained by such policies, others note that most electronic and structural ceramics currently produced in that country are commercial products, and thus are exempt from Japanese strictures on their export.

**Conduct of the Industry**

High prices are an inevitable concomitant of the high performance made possible by advanced ceramics. Those prices are set by the market: while traditional structural materials are available for pennies a pound, advanced ceramics are priced in tens of dollars per pound. This pricing is a function of the cost of research and development, raw materials, and processing, each of which demands a much greater investment than that required by traditional materials.

Market forces also impact upon the ability of the advanced ceramics industry to achieve sales volumes leading to economies of scale: until their costs can be competitive with more traditional and less expensive materials, they will not enjoy the volume of applications that produce such economies. High-volume materials applications, in the main, do not demand the high-performance characteristics of advanced ceramics to the degree that would support the cost of their substitution in most applications. Hence, the volume for any particular advanced ceramic product remains relatively low and specialized, and manufacturers, while responsive to industry requirements for specific high-performance components, have not been markedly successful in marketing these high-cost materials as substitutes for existing materials in established applications.

Because the advanced ceramics industry's success is a function of effective Defense-related research and development programs, it can be argued that government acquisition actions have shaped the practices of the U.S. industry, to its possible detriment in the world market. In the United States, the costs of research and development are borne almost equally by the U.S. government and commercial firms: together, they invest approximately $275 million in advanced ceramics research out of a total materials research and development outlay of approximately $2 billion.

By contrast, Japanese industry bears approximately 80% of the research and development costs in this field, out of a total investment of some $500 million. This radical disparity in both the total research and development investment and the cost sharing ratios reflects an equally radical difference in the research and development strategies employed in the U.S. and Japan. The high ratio of U.S. government investment in ceramics research has been directed towards high-technology applications identified by the Departments of Defense and Energy, a direction paralleled by industry's research and development investments. This is markedly different from Japan, which has employed an "early commercialization" strategy that stresses the early introduction of ceramic components into commercially viable systems and subsequently improving them.

More importantly, both the Japanese government and its industry leaders have recognized ceramics as the "materials of the future" and have made additional investments in research and development without expecting a short term payoff, but with the recognition that without such research and development, Japan cannot retain the competitive edge it now holds in the ceramics marketplace. No such vision is apparent in current U.S. policy initiatives nor does any such vision characterize U.S. industry practices.

As befitting a high-tech industry, management and labor practices, in both Japan and the U.S., appear to be supportive of the industry's aspirations. With a high proportion of scientists and technicians working to develop and improve both its products and its production practices, management-labor bottlenecks do not appear to impede the conduct of business in

this arena in either country. There are, however, claims by Japanese manufacturers that their more highly skilled workforce has achieved substantial reductions in rejection rates, a critical cost factor in ceramics production.

And while the U.S. National Critical Materials Council has identified nine areas of industry concerns focused on government regulations[9], the Committee's analysis reveals that these concerns, by and large, are shared by American industry as a whole: there is no evidence to suggest that the advanced ceramics industry is especially disadvantaged--in comparison to other American enterprises--by current laws and regulations regarding anti-trust, intellectual property, product liability, and information sharing among government, industry, and academia.

Two environmental issues have already engaged the advanced ceramics industry. Advanced ceramics manufacturing starts with ultrafine powders and, in the case of ceramics composites, ceramic matrix whiskers. Such materials require special measures to control the escape of fine particles into the work environment. Such concerns have caused the production of ceramic whiskers to be moved completely offshore. The second environmental concern arises at the end of the useful life of an advanced ceramic component: once ceramics are fired, they cannot be easily recycled back into their basic powder forms. As ceramic components become more common in end items, end-item users will have to address the problems associated with their recovery at the end of the life-cycle.

**Industry Performance**

Ceramics sales figures for U.S. firms were estimated at $3.79 billion in 1990, and $3.91 billion in 1991. Sales are projected to increase at an average annual rate of ten percent (nominal dollars), to over $9 billion by the year 2000. Forecasts indicate that structural ceramics sales will grow at an annual rate as high as 18 percent per year, with engines and wear parts perhaps exceeding 20 percent. The growth in other advanced ceramic applications should remain a constant 8 to 9 percent per year. Composite ceramics are expected to grow at an annual rate of approximately 14.6 percent.[10]

The top ten U.S. advanced ceramic firms, and their 1991 sales, are listed in Table 1. The top four firms account for 52 percent of the U.S. industry's sales, while the top ten firms account for 74 percent. The U.S. industry accounted for 67 percent of the <u>number</u> of top 100 international firms, and 25.5 percent of the <u>sales</u>. It must be noted that the 1991 growth projections were also for an 8 to 10 percent increase. Although total US sales increased by 3.1 percent (real dollars), seven of the top ten firms experienced either no growth or a decline in their 1991 sales. Most firms attributed this to the sluggish economy during 1990-91.[11]

Most of the top U.S. firms are multinational in scope, with examples including Kyocera America, Inc., NGK Ceramics, USA, Cooper Industry, with plants in Europe, and Coors, with facilities in Brazil. Additionally, there has been a noticeable increase in partnerships in the East Asian region.

Table 2 compares 1991 sales of the U.S., Japanese and EC industries. Some of the data are questionable, because the source relies on input from individual firms. For example,

the third ranked international firm for 1991 did not even appear on the 1990 list. The world figures track closely with like statistics from other sources.

*The top six Japanese ceramics firms are all in the top ten in international sales.* The EC figures are skewed by including the number one international firm, Phillips Electronics N.V. with 1991 sales of over $3.2 billion. The United States (8), Japan (6) and the EC (6) make up all top twenty international firms. The highest ranked firm that is not included in one of these categories, is ICI Australia Ltd., with 1991 sales of $34.0 million. Competition between international firms is intense, especially when most larger firms have partnerships or subsidiaries in the US, Europe, and East Asia (but not Japan).

The most prominent call for protection is embodied in Coors Electronic Package Company's request for relief under Section 232 of the Trade Expansion Act of 1962. In that request, the plaintiff argues that Japanese competition has prevented U.S. industry from generating sufficient returns to fund both research and development and capital spending. As it argues in its petition,

> ...[S]ince 1983 alone, at least 21 companies have entered, left, and attempted reentry into this market. Commercial giants such as 3M, General Electric, Tektronix, DuPont, W.R. Grace, Corning, and Raychem failed in their attempts to stay in this sector. Smaller companies such as Cabot Electronic Ceramics and Rhode Island Electronic Ceramics have also failed. Each has experienced the difficulties of fighting Japanese competition...A striking example of a newcomer's inability to contest Kyocera and Japan's market dominance is the case of Hoechst CeramTek. Hoechst, A.G. purchased an integrated circuit packaging operation in Providence, Rhode Island in December, 1984. By July, 1985, Hoechst closed the facility. ...Hoechst was not alone in the difficulties and costs it faced. Generai Electric attempted to enter the industry and was forced out within relatively short periods. Cabot Electronic Ceramics underwent a painful three-year consolidation period before giving up. Cabot was purchased by Microelectronics Packaging of America, the only reason Cabot did not shut down. Demetron, Inc. was also unable to compete with Japanese competition when faced with high entry and maintenance costs.[12]

This is the case made by Coors. It is, however, only one explanation for the performance of the U.S. advanced ceramics industry.

The problem in the advanced ceramics industry could as well be described like that in many other industries, i.e.,impatience. Akio Morita put it best in The Japan That Can Say No: "We are focusing on business ten years in advance, while you seem to be concerned with profits ten minutes from now."[13] A survey of over 500 Japanese and American corporate executives found that American executives clearly ranked "return on investment" as the most important corporate objective with "share-price increase" second. Japanese executives ranked "market share" as most important. "Share-price increase" was last.[14] The U.S. Bureau of Mines contrasts Japan's "innovation-driven" marketing strategy, introducing products and improving them to develop markets, with the U.S. "market-driven" approach, seeking to identify markets for new products before developing them.[15,16]

Several major reasons for the difference in the U.S. and Japanese focus involve the relative cost and nature of capital in each country. Most experts view the cost of capital in the U.S. as much higher than in Japan: one study suggest 50 to 75 percent higher. That difference is attributed to the low rate of savings in the U.S., coupled with its high deficit and differing tax treatment of long-term investment.[17]

In Japan, financial institutions provide long-term capital to firms in which they have an equity position and on whose board of directors they sit.[18] In the U.S., a large and increasing share of capital comes from pension plans and mutual funds with no connection to management, except to promote short term profits and increases in stock values and dividends.[19]

Many U.S. firms are becoming victims of leveraged buyouts by financiers who pay for its stock by issuing high yield "junk bonds" using its profit potential as collateral.[20] These takeovers leave the firm with a large debt, and large payments, that promote a short-term focus. U.S. tax laws make payment to creditors for borrowed money (interest) a deductible expense but not payment to owners of equity (dividends).[21] As a result, companies are greatly expanding borrowing while contracting equity financing.[22]

The U.S. advanced ceramics industry may not need protection so much as it needs cheaper capital and more patient capital to fund research and development and allow time for commercialization. President Clinton's economic initiatives note the "paramount" importance of reducing the deficit and lowering interest rates, yielding cheaper capital, and the need for patient capital.[23,24]

Finally, in an emerging high-technology industry such as the advanced ceramics industry, productivity is more a function of the industry's effectiveness in research and development than it is of more traditional productivity factors. Here, the industry's performance is significant, exhibiting both fundamental strengths and an essential weakness that warrants further attention.

Japanese companies gained early dominance in electronic ceramics through close collaboration among scientific and industrial concerns. In the past, U.S. antitrust laws and divergent industry efforts served to hamper domestic progress in ceramics. Today, however, it is recognized that cooperation within and between industry, universities, and Government is essential to adequately address industrial and scientific concerns and to make progress in this competitive arena.[25] One of the major difficulties in forecasting the extent of ceramic applications and corresponding size of the market for ceramics is the fact that broad usage of ceramics depends on the successful results of materials research and development and test and evaluation still in progress.

Since 1991, over 88% of Federal funding for ceramics research has been centered within DoD, DoE, and the NSF as shown in Table 3. A comparison is shown between ceramics and total materials research and development funding for each of 10 Government agencies for the last three years. Approximately 10% of all Federal materials research and development is directed at ceramics. However, the exact amount spent on ceramics research and development is somewhat nebulous since much of what is reported in other areas of Federal materials research may also include some ceramics research and development, since

boundaries between materials areas are difficult to establish. For instance, instrumentation research and development for characterization of ceramic material properties may be equally applicable to composites. Under which category should it then be listed? A NIST source suggested that the actual ceramics research and development for FY 1992 may be closer to $300 million, more than twice the amount stated in Table 3.

DoE is by far the largest supporter of advanced ceramics research and development. High temperature, load-bearing structural, corrosion resistant functional materials are typical ceramic applications in which DoE is directing its attention. In order to understand such properties, DoE also conducts research on bulk properties, surface crack phenomena, and in-process diagnostics and control of advanced ceramic processing procedures. DoE is also concerned with the safety and reliability of nuclear reactors, and only advanced ceramics offer the requisite attributes to counter radiation-induced phenomena in reactor walls and associated systems.

Because of DoD's constant need to improve performance of military systems, DoD has always pursued the limits of technology. The new DoD technology base program focuses on bearings, anti-corrosion coatings, electronics, survivability and nondestructive evaluation of components.[26] Significant efforts are directed at processing and characterization of advanced ceramics. These include high efficiency gas turbine engines. DoD's systems of the 1990s and beyond require empirical methods for management of heat loads, and only advanced ceramics offer the desired reliability, simplicity and passive thermal management properties.

As a consequence, U.S. research and development efforts have produced new ceramic materials with extraordinary performance characteristics, maintaining a significant edge in technological innovation. But that focus has detracted from its efforts in both applications research and manufacturing research, both of which are essential for the successful introduction of these advanced ceramics materials as high performance substitutes in existing commercial systems. Japan's research and development efforts are more evenly distributed across the development-manufacture-adoption continuum, resulting in more rapid and extensive integration of new materials into existing products.

Recent U.S. government initiatives promoting technology transfer, the development of dual-use technologies, and Cooperative Research and Development Agreements (CRADAs) represent efforts to address this imbalance in our research profile, but those efforts are only beginning, while Japan's more comprehensive approach has been in operation since the late 1970's. In these initiatives, the experience of Canada's National Research Council, its Ministry of Defence, and the Ministry of Industry, Science and Technology (ISTC) would provide models and experiential data worth further study. What remains even more problematic, however, is the funding for research and development in ceramics: while government funding is expected to shrink over the next five years, there is no indication that industry investments in research and development will even begin to approach the levels already achieved by Japanese industry.

Officials of the Industrial Bank of Japan reported that only a very few of the more than 300 advanced ceramics firms in that country were currently showing a profit. What is noteworthy is the fact that such profitability was not a short-term concern for Japanese industry: it was claimed that they were confident in the long-term potential of the industry and

that such short-term losses represented an investment in the future. By contrast, the same low rates of return for U.S. firms can, in large part, account for both the exit of many firms from the market and the sale of others to foreign, especially Japanese, firms.

**Industry Outlook**

The U.S. market for advanced ceramics will continue to grow over the next ten years. The central question, though, is this: will U.S. firms compete successfully in this market, or will their market share continue to shrink? The answer to that question will, in part, lie in the research and development strategies that will be followed in the years to come.

The U.S. advanced structural ceramics market is the fast growing segment, and is expected to grow from $385 million in 1992 to $1.02 billion in 2000, achieving an annual growth rate of 13% over that period. Major market segments are predicted to be cutting tools, wear parts and industrial applications, heat engines, and some aerospace and defense-related applications.

The market for such structural ceramics will be maturing during this period, and will sustain and increase its annual growth rate after 2000 only if research and development efforts are successful in bringing new structural products to the marketplace. The most promising innovations will stem from increased development and utilization of ceramics matrix composites (whose hybrid structures offer new performance levels) and which currently constitute 35% of the structural ceramics market. The market for ceramic composites is expected to grow much faster than that for monolithic ceramics, achieving an annual growth rate of 14.5% annually. But it remains to be seen if U.S. industry's research and development efforts can allow them to participate fully in such growth. That enterprise, at the moment, appears problematic for U.S. manufacturers of advanced ceramics.

The U.S. market for advanced ceramics in the electronic industry is mature, and includes insulators, substrates, integrated circuit packaging, and capacitors. This market, because of its relative maturity, is expected to exhibit an annual growth rate of 8.5% until 2000.

There are some (in the research community but few in industry) who expect further growth in electronic ceramics as the superconducting ceramics, coming into widespread use after the year 2000. But that technology is still only being explored on the small laboratory scale and is generally discounted as a market factor in the next 20 years.

The high-performance ceramic coating technology, the smallest of the advanced ceramic markets, is expected to exhibit an annual growth rate of 9.8%, reaching approximately $450 million by 2000. This growth rate, however, is dependent upon the broader adoption of ceramic coatings in the aircraft engine and aerospace industries, which, together with cutting tool applications, account for approximately 90% of the market.

That growth, however, like the projected growth in the structural ceramics market, is dependent upon research that moves out of the lab and into the marketplace. While researchers were uniformly excited about the potentials of both structural ceramics and ceramics coatings, the producers in the marketplace were much more conservative, preferring,

wherever possible, to go with materials whose cost was lower and whose risks were better known.

There is, in short, a breakdown between the researchers developing advanced ceramics and the marketplace that threatens the growth of this industry. In assessing the outlook for the advanced ceramics industry, the predominant concern is creating an effective and comprehensive response to the manifold challenges in the research and development process from development through manufacturing to marketing, a challenge that the U.S. industry has yet to meet successfully.

Ceramic materials research and development appears to be following a path similar to that taken by the semiconductor industry as it went through its initial stages of research and development. Like semiconductors, advanced ceramics are extremely sensitive to fabrication process control, instrumentation precision required for characterization, starting material purity, contaminants, performance reliability, process reproducibility for mass production, and product integrity. In addition, substrate and process characterization required specialized instrumentation, which had to be developed before significant improvements to chip performance could be made. The same holds true for today's advanced materials, whether ceramics, composites, or bio-materials.

Another area of concern is the multi-disciplinary approach required to conduct research and development on advanced materials. A working knowledge of theoretical and applied physics, chemistry, metallurgy, computational techniques, and structures is essential to effect further advances in materials. Very few people possess such expertise and there is currently no effective means of training people for the future. Technical concerns of reliability and reproducibility, characterization, and raw material purity are especially critical to the eventual acceptance of advanced ceramics in the marketplace.

Fabrication consistency requires extremely precise control of the forming process and purity of starting materials. The slightest variations result in inconsistent intrinsic properties, generate bulk and surface imperfections which are the "weak links" in material performance, and perpetuate the reputation that the fabrication process as an "art" mastered by only a few "artists" rather than an engineering science. This is especially critical in fabricating ceramics acceptable to the marketplace, given their long-standing reputation for unpredictable and catastrophic failure due to inherent inconsistencies in the materials forming the basic ceramic. Thus, end item reliability and fabrication reproducibility are of concern to both the manufacturer and user because of performance and product liability.

There currently is insufficient information to adequately characterize and model material properties. In most cases, ceramic materials are very brittle and their failure mode occurs catastrophically. Much is yet to be learned about ceramics to predict life-cycle and the onset of failure. Thermal, structural, electrical and optical properties can be somewhat "tuned" during the fabrication process, but final properties seldom agree with predicted results. These problems require additional research, as well as a coordinated communication process to distribute known information, such as material properties and who is conducting various aspects of ceramic materials research and development. An effective communication network would significantly reduce duplication and shorten the learning curve for most advanced materials researchers. To aid in the communication process, a common, standard definition

for ceramics is needed.

But that communication network, valuable as it is within the nation's laboratories, must also reach out into the community of users, connecting with them much earlier in the development process than is now the case. There is a disconnect between the laboratories and the marketplace which is compounded by the inherent conservatism of the marketplace: a successful product is one whose capabilities and limits are known and accepted by both manufacturer and customer. Until there is better communication about the state of ceramics research, initiated by the research establishment, the manufacturers will tend to err on the side of caution, working with materials whose properties are clearly and unequivocally established in their minds.

Integral to this process of timely and credible information sharing with the marketplace is the arcane but critical task of materials characterization. The characterization of advanced materials is a whole area of research and development unto itself. Development of new materials with exotic, nontraditional and diverse properties requires improved nondestructive evaluation (NDE) technology and equipment currently unavailable.[27] Conventional NDE techniques, such as acoustic spectroscopy, are inadequate when studying bulk properties of ceramics. Materials characterization through improved NDE techniques is required to help improve the quality and reliability of ceramic products.

This is equally relevant to the marketplace, where manufacturers bear the burden, legally and commercially, for the consistent quality of the products they market. Until the research and development efforts directed at materials characterization are transferrable to quality assurance methods usable in the manufacturing process, advanced ceramics will pose an unacceptable risk, real or imagined, of product failure. Such a perception of risk is an insurmountable barrier to market entry.

Laboratories can purchase, in small quantities, any substance they require of the quality they need for their research. For large-scale manufacturing, raw material availability is of primary concern. In the production of advanced ceramics, the purity of the raw material is essential for product reliability, as structural strength depends upon the finest degree of consistency within the powders processed into ceramic shapes. Many critical powders and materials required for production of advanced ceramics are not currently available in the U.S. Therefore individual powder manufacturing processes and related technology efforts may have to be undertaken to develop requisite materials prior to production of ceramic parts. In addition, scale-up and cost reduction procedures need to be developed to transform laboratory results and procedures into efficient, mass production of both powders and finished products. This is even more critical, given the already extremely high and thus uncompetitive materials costs associated with advanced ceramics, a fundamental barrier to their wide-spread substitution in the marketplace.

It is in the area of research and development that economic and technological concerns combine to create special problems for the advanced ceramics industry, obstacles which must be surmounted by visionary practices in both spheres if the industry is to achieve the competitiveness its technology promises.

First and foremost, advanced materials research and development is expensive. Advanced materials research, and especially ceramics, require research and development methods that are often quite different from conventional types of research and development. It depends on multi-disciplinary approaches utilizing various technical backgrounds, resulting in high personnel costs. Further, it entails a range of exotic processing techniques such as very high to very low temperature treatments, which in turn demands large investments in capital equipment. Further, nonconventional instrumentation is required, or must be developed, to evaluate material properties. Such unique and specialized equipment is expensive to buy, operate, and maintain. Then there is the issue of research and development funding priorities when programs have to compete for sponsorship in a difficult time of reduced budgets. In addition, research and development on advanced materials is always speculative and thus entails a high risk that may not pay off, unless breakthroughs are encountered.

The second economic obstacle to the growth of the advanced ceramics industry is the length of time it takes to transition newly developed technologies into marketable products. From the time of a new basic discovery, it can take typically more than 10 years to commercialize a product from that discovery. As noted by other Industry Study teams, product innovations in other fields can be introduced into the market within a year, and most such introductions are accomplished within three years. With industry's near-term focus on marketing innovations, there are few long-range planners within industry to support ceramic or other advanced materials research and development.

Traditionally the Government conducts basic research while industry follows up with applied research and development. Transferring any Federally developed technology to industry is a complex and cumbersome process at best. Although efforts have been initiated within the last few years to remedy this, much is yet to be done to realize a successful technology transfer process which substantially benefits industry. In addition, users will not adopt newly developed ceramic components until the parts perform at or above expectations, which requires extensive certification testing, especially if the part is a critical component such as a turbine blade of a jet engine. This testing adds to the delay time from discovery to application.

The final economic hurdle, transparent to too many researchers in the field, is to be found in the dynamics of the marketplace in which advanced ceramics compete with other materials for market share. Marketing ceramic parts or other advanced material components to manufactures of systems, such as high performance engines may be extremely difficult. Not only must the component's performance be superior, but its value added in conjunction with the cost of integration and changes in assembly procedures and operations must be considered. Industry will ask if the investment justifies the changes. In addition, there are as yet no standards or specifications to assign to many ceramic materials, since they have not yet been developed. Although the potential market for ceramics is tremendous, ceramics technology has not reduced industry's risks and costs so as to make industrial firms want to readily adopt these materials.

In short, the Committee contends that it is the integration of the laboratory and the marketplace that will most profoundly impact the U.S. advanced ceramics industry's outlook over the next twenty years. At present, there are reasons for concern.

Dominating the list of such concerns is the current dependence upon governmental investment in research and development, a dependence which contrasts sharply to the substantial investment currently being made by Japan's industry in such research and development efforts, all directed towards eventual application in the marketplace.

This problem is compounded by the lack of "patient capital" for such efforts in the U.S. As noted above, the development time for advanced ceramics is much longer than that for other products under development. Japanese industry appears willing to patiently await such development; industrial investors in the U.S., by contrast, appear to take their profits and run, selling off their advanced ceramics holdings to foreign interests rather than "staying the course" through to eventual market success.

But the "research culture" prevalent in the U.S. is an equal part of the challenge facing the industry. Driven by Federal dollars, the research community has focused either on basic research or on specific DoD and DoE applications, all of which are "public goods" rather than potentially competitive market entrants. Thus the research community has an extraordinarily narrow focus, one that ignores the equally challenging problems inherent in manufacturing and marketing.

It is the Committee's contention that the very real strength of the research and development community in the United States retains the potential for establishing and maintaining the U.S. advanced ceramics industry as a world leader. But that potential will remain unrealized unless there are significant changes in the research and development culture prevalent in this country, supported by equally significant changes in the economic support available to that community. Will that happen?

**Industry Strategies for Survival**

While some might characterize the strategy of most U.S. advanced ceramics companies as "selling and getting while the getting is good," there is some reason for mild optimism apparent in the behaviors of some industry members.

First and foremost, there is a gradual restructuring of the research and development efforts within the industry. The research resources assembled by the government over the last half century are finally free to assume more of a market orientation through their promotion of Cooperative Research and Development Agreements (CRADAs) with private industry. Such agreements, if successfully seen through to marketplace applications, will represent a redirection of government research resources towards the marketplace, paralleling the eminently successful marketplace orientation historically exhibited by Japanese research and development efforts. While it is too early to judge the success of such cooperative efforts, CRADAs do represent a significant attempt to direct the real research and development strengths of the U.S. towards the marketplace, and not merely towards the narrowly defined "public goods" represented by DoE and DoD.

Secondly, those elements of the advanced ceramics industry still under U.S. ownership have evidenced an increasing willingness to engage in "teaming." The most notable example of this initiative is W.R. Grace's exploitation of its substantial research and development capability with the excess production capacity enjoyed by Coors Electronic Package

Company, resulting in a laboratory-to-market effort that should serve as the model for other U.S. companies.

Finally, the emergence of "materials and manufacturing consortia" at many U.S. universities, jointly funded by those institutions, industry, and government, draws on the traditional commitment of American universities to the advancement of both science and economic well-being as well as their strengths in basic research, shaped through such consortia to the market needs defined by the participating industries. Such consortia are a uniquely American innovation which have no counterpart in Japan, and which long ago, through the Agricultural Extension Service, proved their efficacy in promoting both scientific advances and economic progress. There is thus historical precedent for mild optimism about their contributions to the emergence of a competitive advanced ceramics industry in this country, one which draws upon the marketing sensibilities of American industry, the research skills of American universities, and the focused support of the U.S. government's research agencies.

But these are only emerging and nascent strategies whose employment is relatively recent and often dwarfed by the strategy of retreat favored by too many short term profit takers in U.S. industry. Their ultimate success remains a matter of conjecture, but there are some things that the U.S. government can do to advance such positive strategies, and that is the focus of our policy recommendations.

**Government Response**

If the United States is to realize the promise of technology for our nation and the economic sustainment and betterment of its people, the Federal government needs to act decisively and rapidly to reinvigorate and redirect support for effective research in the field of advanced materials for their ultimate use in products and processes that are viable in the international marketplace. It is recognized that the future economic well-being, as well as the national security of the United States depends upon our ability to compete successfully in the international industrial marketplace. Our strength as a nation has historically been founded upon our industrial competitiveness and productivity, starting with our basic research and flowing through our superiority in both manufacturing and product marketing. Governmental policies have always played a role in establishing such competitiveness, and they are still required in today's international markets.

First, the Federal government must develop a well thought-out, overarching, technology policy that has not only the support but the commitment of the major players in the industry. This policy must be translated into a complementary technology plan that leads to an optimization of investment in advanced materials research that will rival Japan's commitment to "the materials of the future." Such a plan must require proactive participation from all levels of the Federal structure, ensuring the effective redirection of Federal resources whose historic focus on defense issues must be reoriented to the larger issues of economic competitiveness. There is currently no such cogent policy or plan in place; given the dynamics of the international marketplace, it is long overdue: its absence leaves the national economic will unfocused and ineffective.

Secondly, with such a policy and plan in place, the Federal government should move

to restructure its regulations and procedures governing cooperative agreements between industry and government to facilitate technology transfer under its overarching technology policy. Reducing such "red tape" would entail streamlining agreement processes, decentralizing execution, and simplifying agreements in order to facilitate their productive and timely execution. Cooperative research and development agreements (CRADAs) should be reframed as instruments of that technology policy, rather than as regulation-bound acquisition contracts. In assessing such cooperative efforts, a joint industry/university/Government forum should be brought into being where agreement could be reached on mutually acceptable research and development priorities and the assignment of responsibilities between parties to such cooperative efforts. To focus the very real strengths of the federal laboratory establishment, "centers of excellence" should be established within that structure to prevent duplication and to ensure that a critical mass of research competence is maintained in essential research areas. Concomitant with the creation of such centers, further economies may well be accomplished through the elimination of duplicative efforts within the federal laboratory complex, thus making better use of increasingly shrinking federal research dollars.

Thirdly, the nation's technology policy must recognize the realities of a truly global, transnational economy and develop strategies for effective competition in that arena. Such a policy must define new ways to accept and promote foreign technology transfer. By reducing barriers, we can gain access to generic and some applied materials research developed outside our borders, gaining synergy through the cooperative contributions of U.S. researchers and their foreign counterparts and thus increasing the efficiency of research efforts in this field. Such a policy would increase research and development by encouraging competing companies to shake hands during the pre-competitive phase, and begin their competition only in earnest when they move into market development. This is the strategy of Japanese firms, some of the most competitive organizations in the world market. It bears emulation in this country, for it would draw upon our real strengths in both basic research and consumer marketing.

Finally, current levels of Federal research and development spending should be maintained, not as a matter of national security as it has been narrowly defined in the past, but as an investment in the future where our real national security lies. With such an investment as a focus, Federal laboratories should commit themselves to the pursuit of dual-use technologies, thus addressing both our short-term defense needs and the larger issues of economic survival. Like Japan, the U.S. must resist the temptation to cut back research and development funding during slow economic periods: wielding this vision of "an investment in the future", it should provide tax incentives to encourage long-term research and development investments within industry.

In pursuit of this vision, the government has instruments already in place--ARPA in DOD and the Advanced Technology Program in DoC--that have the experience in coordinating and directing major research efforts; that experience can now be turned towards supporting the efforts of business firms, small and large, to acquire and successfully market the products emerging from our unparalleled research resources already existing in industry, universities, and government laboratories. Facilitating technology transfer, providing forums for the exchange of technical information, speaking cogently on behalf of the research establishment in this country, these Federal agencies can make such an investment in the future happen.

But governments can only do so much: in a free market, it is the players themselves who ultimately shape the future of the advanced ceramics industry. And thus the government, and especially DOD, must remain acutely sensitive to trends within that industry. Some trends are already apparent: while the U.S. continues to have unparalleled basic research capabilities, the products of that research are increasingly being manufactured by companies owned by foreign or transnational interests. Thus advanced ceramics technology is available on the global market, but our access to that technology in times of crisis may depend more upon international economics, politics and diplomacy than on any internal U.S. policies. Thus the nation must watch this field carefully as the products of its research push technology to the edge in the pursuit of high performance in order that we may continue to have access to that technology when we need it.

## TABLE 1

**Top 20 U.S. Ceramics Firms**
(1991 Ceramics Sales)

| Firm | U.S. Ranking | Int'l Ranking | Sales (millions) |
|---|---|---|---|
| Corning, Inc | 1 | 4 | $1000.4 |
| Cooper Industries | 2 | 7 | 456.0 |
| General Motors | 3 | 10 | 308.0 |
| GTE Corp. | 4 | 12 | 275.3 |
| Allied-Signal | 5 | 16 | 212.5 |
| Coors Electronic | 6 | 17 | 180.2 |
| Kemet Electronics | 7 | 19 | 146.0 |
| CTS Corp. | 8 | 20 | 112.6 |
| Dover Technologies | 9 | 21 | 105.0 |
| Keystone Carbon | 10 | 22 | 100.0 |

Source: "10th Annual Giants in Ceramics," Ceramic Industry, (August 1992: pp. 28-29).

**TABLE 2**

**International Sales**
(nominal dollars - millions)

| | 1990 | 1991 | 2000 (proj) |
|---|---|---|---|
| World Sales | $13,600 | $15,342 | $29,900 |
| U.S. Firms | $3,790 | $3,911 | $9,202 |
| % of world total | 27.9% | 25.5% | 30.8% |
| Japanese Firms | $4,527 | $6,685 | na |
| % of world total | 33.3% | 43.6% | na |
| EC Firms | $5,423 | $4,627 | na |
| % of world total | 39.9% | 30.2% | na |

Source: "10th Annual Giants in Ceramics", Ceramic Industry, (August 1992: p. 28.)

TABLE 3

## FEDERAL R&D FUNDING FOR CERAMICS/ADVANCED MATERIALS
(Millions of Dollars)

| Agency | FY 1991 Ceramics | FY 1991 Total | FY 1992 Ceramics | FY 1992 Total | FY 1993 Ceramics | FY 1993 Total |
|---|---|---|---|---|---|---|
| DoC | 4.4 | 33.4 | 4.4 | 34.2 | 5.8 | 38.4 |
| DoD | 30.1 | 505.9 | 20.4 | 448.6 | 22.4 | 431.9 |
| DoE | 78.1 | 361.8 | 80.0 | 380.3 | 90.6 | 423.8 |
| DoI | 2.7 | 25.0 | 2.8 | 24.7 | 2.1 | 23.8 |
| DoT | 0.0 | 10.0 | 0.0 | 8.8 | 0.0 | 15.5 |
| EPA | 0.8 | 3.2 | 0.8 | 3.5 | 0.8 | 4.5 |
| HHS | 0.0 | 66.6 | 0.0 | 76.6 | 0.0 | 81.7 |
| NASA | 6.4 | 116.4 | 7.5 | 124.5 | 9.3 | 153.5 |
| NSF | 14.6 | 216.0 | 16.5 | 243.1 | 19.5 | 291.7 |
| USDA | 0.0 | 51.4 | 0.0 | 57.1 | 0.0 | 66.1 |
| TOTAL | 137.1 | 1389.7 | 132.4 | 1401.4 | 150.5 | 1530.9 |

Source: Advanced Materials and Processing: The Fiscal Year 1993 Program.

## ENDNOTES

1. As defined in the National Critical Technologies Panel Report to the President, March 22, 1991; US Department of Commerce, "Emerging Technologies: A Survey of Technical and Economic Opportunities", Spring, 1990; and US Department of Defense, "Critical Technologies Plan", 15 March 1990.

2. Estimates of the number of advanced ceramics firms, even in the U.S., varies between a hundred and a thousand. For the purpose of this report, industry projections will be based on those firm with sales of advanced ceramics of US$2 million in 1991, as listed in "10th Annual Giants in Ceramics", Ceramic Industry, August, 1992: pp. 23-31.

3. M.J. Attardo, Office of the IBM Vice President , General Manager, Technology Products, Letter to the U.S. Department of Commerce regarding the effects on the national security of the United States of imports of integrated circuit ceramic packages. 15 Jan 93.

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6. Randolph J. Stayin, Counsel for Kyocera Corporation, Letter to the U.S. Department of Commerce regarding Investigation of Imports of Integrated Circuit Ceramic Packages under paragraph 232 of the Trade Expansion Act of 1962. 1 Feb 93.

7. Strategic Analysis Division, Office of Industrial Resources Administration, U.S. Department of Commerce, National Security Assessment of the Domestic and Foreign Subcontractor Base: A Study of Three Navy Weapon Systems, p.88.

8. William Wellock and Bruce Deckman, "Global Competitiveness and Its Impact on High-Performance Ceramics," Ceramic Bulletin, 71:1, pp. 103-04 (1992).

9. The Advanced Materials Program Plan ...The Continuation of a Presidential Commitment, National Critical Materials Council, Executive Office of the President, 1989.

10. Thomas Abraham, "The US Advanced Ceramics Industry", JOM, Jan., 1992, p 7.

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12. Coors Electronic Package Company and Ceramic Process Systems Corporation, "Petition under section 232 of the Trade Expansion Act of 1962 regarding Integrated Circuit Ceramic Packages" Public Version Before the United States Department of Commerce, Office of Industrial Resource Administration, November 10, 1992. pp.53-4.

13. Quoted in Kenneth R. Adelman and Norman R. Augustine, The Defense Revolution: Strategy for the Brave New World (San Francisco, CA: ICS Press, 1990), 117.

14. Michael L. Dertouzos, Richard K. Lester, Robert M. Solow, Made in America: Regaining the Productive Edge (Cambridge, MA: MIT Press, 1989), 63.

15. U.S. Bureau of Mines, The New Materials Society: Challenges and Opportunity, Volume 1 (Washington, DC: U.S. Government Printing Office, September 1990), 2.22.

16. Typifying the difference in approach, in the 1970s and 1980s, government research in the ceramic engine for automobiles and in ceramic armor for tanks led to "Ceramics Fever." Industry became obsessed with these high-end products, which seemed certain to generate huge profits in the 1990s. When these projects went away in the late 1980s, so did much of the interest of American industry. (Thomas Abraham, "Current U.S. Markets for Advanced Ceramics and Projections for Future Growth," 4-5.) Meanwhile, Japanese firms pursued the less sexy electronics field and now dominate that world market, $3.7 billion in the U.S. alone. (U.S. Bureau of Mines, 2.17 & 2.22)

17. Dertouzos, et.al., 60-61.

18. Ibid., 61.

19. Ibid., 62.

20. William J. Baumol and Alan S. Blinder, Economics: Principles and Policy, Fifth Edition (San Diego, CA: Harcourt Brace Jovanovich Publishers, 1991), 646.

21. 26 USCA 163(a), 26 USCA 562.

22. Baumol and Blinder, 637.

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24. Ibid., 13.

25. Thomas W. Humpherys, "Transferring Technology to Private Industry: Does Reality Threaten Expectations?" Unpublished report prepared for the Industrial College of the Armed Forces, 1993.

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27. Rustu S. Kalyoncu, *Advanced Materials*, pp. 12-13.

# National Defense University

# Industrial College of the Armed Forces

# China Survey Trip Report

May 1993

## ICAF MEMBERS OF CHINA SURVEY TRIP

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[Note: Also participating were a NWC Faculty Representative as the delegation leader and 10 NWC students.]

## INTRODUCTION

The 1993 National Defense University China survey trip took place from 30 April to 15 May 1993. The group consisted of 10 students and one faculty member each from both the Industrial College of the Armed Forces and the National War College.

This report synthesizes the ICAF students' observations into a single compilation of key issues and concerns. It incorporates valuable insights that the U.S. Ambassador to China, Stapleton Roy, offered the group as part of our initial country team inbriefing at the U.S. Embassy in Beijing. It ends with our recommendations for appropriate courses of action by U.S. policy makers.

## TRIP OVERVIEW

To say we had a busy schedule while in China is an understatement. On average we flew to a new city every other day. The schedule was a reflection of the People's Liberation Army's (PLA) desire for us to see as much of China as possible. We visited Beijing, Xi'an, Chengdu, Shanghai, and Guangzhou; and completed our trip with a short stop in Hong Kong. Each new location provided unique perspectives and situations that shaped our individual and group perspectives.

We had discussions with some of China's preeminent civilian and military strategic thinkers, as well as with key members of professional military institutions. We saw first-hand the Chinese commitment to modernize their commercial industrial base and infrastructure. U.S. Embassy and Consulate country teams provided an excellent balance of the U.S. perspective on various Chinese projects and priorities. In Hong Kong, the U.S. Consulate arranged briefings that greatly facilitated our understanding of the complexities remaining in the reunification of Hong Kong with the People's Republic of China.

The time we spent in China and Hong Kong proved to us that there is only one certainty for the PRC. It is the reality of change. Today's economic reforms are the precipitators of rapid changes and modernization. We saw significant impacts in political, national security, economic, and social arenas. Our observations focus on these four critical areas.

## AMBASSADOR ROY'S OBSERVATIONS

At the beginning of our trip, the U.S. Ambassador to China, Stapleton Roy, offered us some very useful observations on China. They framed a perspective that proved very pertinent and valuable throughout our survey visit. In summary, he said: 1) China is the most difficult country in the world to come to grips with, but it is the most interesting country. 2) Communism has collapsed throughout most of our world, but not in China. Instead, it is evolving. 3) China is the only communist country which has successfully tried free market enterprise. 4) U.S. sentiment about China is generally negative when you are reminded of the events in Tiananmen Square, and positive when you consider the incredible improvements made in the lives of the Chinese people. 5) China's economy has grown at an average of 9 percent per year since 1979; 12.7 percent in 1992! and 6) Natural resources abound; transportation and communication industries are expanding. However, American investors are wary because of the annual MFN Congressional debate.

## POLITICAL OBSERVATIONS

### China Is Evolving

China is evolving from a closed, communist state to a more responsible and open country. The most visible element of this evolution is China's free market economy. The new Chinese policy of political openness extends to a willingness by government officials to discuss problems, budgets, and future plans. This openness also extends into the economic sector where capitalism, led by the special economic zones, is rapidly expanding and changing the face of Chinese communism.

Individual freedom is still controlled; however, the move to capitalism and openness has somewhat eased the hard line controls placed on individuals. The younger generation is willing to question social problems, political change, and Beijing's absolute authority over their lives.

The police state one would imagine after the Tiananmen Square incident is non-existent. Uniformed traffic police are noticeable on the streets, but soldiers carrying weapons are not visible. However, the totalitarian threat of another Tiananmen crackdown still exists.

### Communist Party Is In Control

Make no mistake, the communist political party is still in control. The absolute control that the Beijing central government exercised in the past has declined, especially in the special economic zones. Provincial leaders now have more say in how their local government operates. Political change in China is unavoidable, driven by economic reform and free market forces. The eventual passing of the geriatric top leadership will probably usher in a more westernized, pro-modernization, and reform minded communist government.

### One China

The overall goal of the Chinese communist government remains unchanged -- to reunite mainland China, Hong Kong, Macao, and Taiwan into one China. In 1997 the British will return Hong Kong to the PRC. By written agreement, Hong Kong will retain it's own political, legal, and economic systems for 50 years. This is the prototype of the "one country, two systems" concept that the Chinese hope to use for the eventual reunification of all traditional Chinese territory. China's handling of the Hong Kong issue will be an important indicator of her future regional intentions.

### Chinese International Issues

The Chinese disagree with international concern over human rights, trade, nuclear proliferation, hegemony, and questionable arms sales. They view each of these as internal issues. The Chinese believe that their actions should be judged based on progress and improvement over time. They are quick to point out that nuclear transfers and arms sales occur within existing international agreements.

## NATIONAL SECURITY OBSERVATIONS

### Chinese View of U.S. Role in Region

The Chinese have a fundamental view of sovereignty -- "no country should station troops on foreign soil." Expressing a fear of the re-emergence of Japan as a military power, the Chinese posited that the U.S. should gradually withdraw the number of troops stationed in the region. Pressed to explain the perceived disconnect of this position and their abstention in the United Nations Security Council voting that allowed support for OPERATION DESERT SHIELD/STORM, the Chinese rationalized their action by indicating their abstention avoided the issue. (Although the Shanghai International Institute for Strategic Studies acknowledged that it can be perceived as a disconnect.)

We attempted to determine what the Chinese felt the U.S. military role would be after the gradual withdrawal of American troops from the region. They did not provide a definite answer; nor were they forthcoming in differentiating between forward deployment and forward presence.

The Chinese saw the 1992 sale of F-16 fighter aircraft to Taiwan by the Bush Administration as destabilizing to the region. They saw it as a violation of the 1982 bi-lateral communiqué because the U.S. failed to pre-discuss the sale with the PRC.

### Chinese View of Their Role in the Region

Chinese national security issues are regional. The perception is that they will achieve international recognition as their market economy expands and as their forces modernize.

The basis for Chinese national security strategy is the concept of "5 Pillars" -- respect for national sovereignty; non-aggression; non-interference in internal affairs; mutual respect and equality; and peaceful coexistence. This basic philosophy expresses how the Chinese view their regional role and relationships with their neighbors. But the strong, subtle inference was that this is how the United States should deal with China.

The Chinese postulate that potential conflicts in the area will occur on the periphery of China and will involve limited military actions. They believe these actions will be lethal and of short duration. They maintain a defensive strategy based upon an active defense; although this might be more a factor of the lack of infrastructure within the country and the Chinese inability to move forces rapidly. The Chinese indicated that the U.S. and regional nations should not view China as a threat.

The Chinese are seeking to regain their military pre-eminence. A major factor of this is their force modernization effort. While they are making significant inroads to incorporate modern technology into their armed services, they are about 20 years behind the technological curve. The videotape of their satellite tracking operation showed an old-fashioned telephone switchboard and teletype communications. Also, the reserve PLA division took us proudly to a room for teaching Morse code.

Noticeable during our tour of the F-7 (read MiG 21) fighter aircraft factory in Chengdu was that workers were not using templates to rivet/bolt the skin to the frame -- the worker merely eye-balled the next position.

Chinese involvement with the proliferation of weapons of mass destruction potentially represents a major threat to U.S. national security interests. The official Chinese position toward nuclear weapons is no "first use". However, the U.S. regards China as a potential a nuclear threat because of her Communist ideology and sophisticated missile technology. Her missile and nuclear technology exports to North Korea and the Middle East have also caused nonproliferation concerns. Before joining the International Atomic Energy Agency (IAEA) in 1984, many of China's nuclear and missile sales were considered suspicious. Since that time, China said it would not conduct or encourage nuclear proliferation; however, she continued to transfer missile technology to several countries and did not sign the Nuclear Nonproliferation Treaty (NPT) until March 9, 1992. The following is a brief review of her past proliferation record.

- Pakistan received Chinese assistance in the construction of its Kahuta uranium enrichment plant that some think contained technology stolen from U.S. labs. China is also cooperating with Pakistan on the M-11 short range ballistic missile program.
- Algeria also received China's assistance in the construction of a nuclear reactor. This occurred before China's IAEA signing, but doubts exist as to the purported use of the reactor. It was "protected" by a near-by SAM site, was not connected to a power station or located in a heavily populated area, and was too large to be used only as a research facility.
- In 1991, press reports suspected Chinese involvement with Iran's nuclear reactor and weapons programs. China has admitted to peaceful commercial transfer of nuclear equipment and technology. But, actual nuclear weapons transactions with this revolutionary state paint a suspicious picture.
- When Iraq could not gain contracts from the West for uranium enrichment equipment, China stepped in and provided the equipment.

China was not a signatory of the April 1987 Missile Technology Control Regime agreement. However, she has recently agreed to abide by its technology export restrictions in order to maintain Most Favored Nation (MFN) trade status.

Discussions during the China trip frequently revolved around China's relations with North Korea and its nuclear status. The Chinese military and political science experts that we met were in general agreement that U.S. heavy pressure against North Korea was ineffective. The Chinese recommended that America use mutual dialogue and patience in its negotiations with North Korea. The Chinese also indicated that they could exert only a limited amount of influence on the Koreans. This was somewhat surprising but indicative of the autonomy and independent status that North Korea holds in the Asian community. Perhaps it is also indicative of disagreement with China's transition toward a more capitalistic market economy.

Chinese military and civilian strategic studies representatives indicated that China

is not now prepared to advocate a collective security arrangement for the region. Instead, she intends to rely upon a series of bi-lateral agreements.

### Additional Issues

We visited a PLA air force engineering school and a naval academy for training junior surface warfare officers. Both acknowledged that they have a great deal of work to approach the educational standards of the U.S. It was also apparent they are making progress in upgrading equipment and renovating facilities. During discussions with the Guangdong PLA reserve division headquarters it was interesting to note that the division maintained that they could activate their entire division within 72 hours. This seemed like an overstatement of their response capability.

It was interesting to note that all three arms of the PLA (army, air force, and navy) were involved in the commercial sector. The Guangdong reserve PLA division indicated that it owned and operated a building housing commercial enterprises, plus acknowledged their involvement with various major construction projects in the area.

### Perceptions

The Chinese have a clear vision of where they want to go with regional security. It is essentially based on their pre-eminence within the region. Provincial PLA units have much autonomy in terms of expanding their influence beyond the traditional military role for national defense.

The Chinese desperately want more contacts with the U.S. military. They seek mutual understanding. It was evident that they hold a high regard for the U.S. military. They advocated remission of the United States' prohibition against military and high-level national security exchanges.

## ECONOMIC OBSERVATIONS

### Socialist Market Economy

The Chinese have taken Deng Xiaoping's "Socialist Market Economics" to the streets. Vendors in every city we visited were selling food, souvenirs and clothing on street corners, in train stations, at national monuments, and in well stocked stores. Street vendors were not the only Chinese hawking consumer goods and exhibiting a capitalistic spirit. Managers at the High Tech Enterprise Zone in Chengdu were working hard to attract foreign investment in high technology projects by offering tax incentives, new facilities, low overhead, uninterrupted power supply and lucrative business opportunities.

Managers at both the state owned F-7 aircraft plant and the Hudong Shipyard told us about their plans to expand their use of excess plant capacity for profitable civilian production. The F-7 plant also participates in a successful joint venture with McDonnell Douglas to build MD-80 aircraft nose cone sections. These managers were preparing for the time when the central government would no longer automatically subsidize production losses at state enterprises.

The PLA is also benefiting from the shift to market economics. We visited a newly built PLA reserve division headquarters and training center in Guangzhou paid for from successfully run PLA enterprises, local government money, and central government funds. The PLA sublets excess space in the building for various commercial enterprises. The money earned from these endeavors helps fund PLA requirements.

The city of Guangzhou, located in Guangdong Province, was the original testing ground for market economics in 1979 with the introduction of three special economic zones. Here we heard about an aggressive 20 year modernization plan to expand port facilities, roads, and energy production. It also called for increases in the annual salaries of workers, improved educational opportunities, and modernized telecommunications.

### "Greater China"

The Chinese stated that foreign investment of approximately $10 billion (U.S.) is necessary to bring about capitalism in Guangdong Province. Much of the required investment will continue to come from ethnic Chinese living outside mainland China, primarily in Hong Kong and Taiwan. The economic links between Guangdong province and Hong Kong, and Fujian province and Taiwan, have created a "Greater China" region that virtually ignores geographic boundaries. The majority of China's foreign investment comes from ethnic Chinese living in other countries and about 60% of China's exports go through Hong Kong. The economic interdependencies of the "Greater China" area dictate that economic developments in one area will affect the economic developments in the remaining areas. This is particularly significant when debating the pros and cons of granting Most Favored Nation status to China.

## Decentralization

The economic independence of the Greater China region is an outgrowth of Deng Xiaoping's decision to open China's "Red Door" to foreign capital. In order to accomplish this goal, provincial governments are now allowed more autonomy than ever before. Decentralized decision making has contributed to China's dynamic economic growth rate and forged strong working relationships and business partnerships with overseas businesses.

## Impediments to Reform

The result of Deng Xiaoping's "Four Modernizations" has been more than just incredibly high economic rates and a construction boom. The rapid growth has also resulted in problems that could derail continued economic progress -- at least for a while. The key concern is inflation. The lack of macroeconomic tools and financial systems hampers the central government's ability to effectively control inflation. We experienced the "adjustable exchange rate" problem with Chinese money. Two types of currency are in circulation throughout China, the RMB ("people's money") and the Foreign Exchange Certificates (FEC). Both currencies have their own value, though the local Chinese population prefer FEC or "hard" foreign currencies because the two-tiered system provides a higher exchange rate for them.

Fourteen years of economic progress have exposed other problems. Among these are unemployment, poor sanitation conditions, widely variant incomes, poor manufacturing quality, and limited technology transfer. No problem looks worse to visitors than environmental pollution.

Visibility was poor and air pollution was evident in every city that we visited. While government representatives we met touted the serious effort that China is putting forward to protect their environment (they mentioned an initial investment of $2 billion (U.S.)), little effort is evident.

Government officials realize that China faces monumental environmental problems as it moves toward industrialization. The Chinese created a new Environmental Protection Agency in 1990 and passed "strict" laws to control pollution at new sources. However, China appears to lack an effective means to enforce pollution standards.

It is apparent that provincial governments will trade economic growth over environmental improvements. Wherever we went, factory smokestacks belched out heavy air pollutants. In the factories we saw work taking place without safety protection; acids stored uncovered in vats; and a lack of waste management. Chemical disposal was nonexistent.

China's challenge in the future will be to find a way to balance industrial growth and affluence with greater environmental protection. She will likely face greater pressure internationally to help with global environmental problems.

## SOCIAL OBSERVATIONS

### Demographics

At about 1.2 billion, China's population is approximately one quarter of the world's total. As of 1992, projected growth rates were 1.6 percent, with the country's population expected to double in only 44 years. Chinese leaders claim the nation's birth rates have stabilized, but they offered minimal explanation of achieving the reductions. We did confirm that abortions remain common and even encouraged. We were told about the substantial tax incentives offered to childless and single-child families. Punitive measures, to include sterilization and additional tax burdens, are routinely imposed on Chinese families with two or more children.

China is urbanizing rapidly. In 1992 metropolitan areas grew by 26 percent. The impact of this growth is particularly significant when considering that over 90 percent of China's people crowd into the eastern and south eastern sections of the country.

### Standard of Living

Though hunger is no longer a problem across China, most Chinese continue to focus on meeting basic needs. Lifestyles remain simple. Bicycles are the standard mode of family transportation. Apartments are small, and most families share a common bath facility. Those with a small refrigerator are considered well-to-do. However, we learned that sales of small household appliances are up significantly, especially in the rapidly developing special economic zones.

Per capital GNP remains under $500. However, the number of private enterprises is growing dramatically. Families are supplementing their incomes by operating street-side stands and shops. And with this disposable income comes the demand for luxuries. Motorized cycles are replacing bicycles; telephones and televisions are everywhere.

China's overall education goal is to ensure all children receive a sixth grade education. But interesting changes are already occurring at the university level. There is a greater interest in business degrees instead of the old Marx-Lenin political doctrine studies. Students are no longer told where they must work after graduation. Consequently, many are striking out into private business ventures and expect to enjoy significant financial successes in the years to come.

Bicycles remain the vehicle of choice throughout China. And there are millions on the roads every day! They provide a practical way of getting around and a viable system to transport goods and commodities to the thousands of small business enterprises springing up the cities and villages. But the number of motorized vehicles is growing. Buses and electric trolleys make up the bulk of the large cities mass transportation network. Trucks are common, especially to support construction projects and large scale agriculture deliveries.

The transportation infrastructure is growing at a tremendous rate. Over 20 new airports are currently under construction. City and provincial leaders plan subway

systems for the large cities. The absence of an infrastructure consisting of well developed road, rail, and air systems pose serious problems for China. If this infrastructure isn't rapidly expanded, the cities, and perhaps even the country's, economic developments will grind to a halt!

**Corruption**

Corruption by government officials remains pervasive through out China. Since party officials at the municipal and provincial level exert significant control over economic development, the opportunities for influence peddling are rampant. Government approvals are required for almost everything involved with starting and operating a business. Business licenses; allocation raw materials, supplies and utilities; and transportation priorities are all essential, and Communist Party officials control their approval. This might help explain why nice cars and private education opportunities for the children of party officials exist for party leaders supposedly working in "low- paid" government positions.

So far in China's rapidly expanding economical development, there hasn't been a large public outcry over this official corruption. This is primarily a result of the prosperity that businesses have enjoyed so far. They seem to follow the adage that as long as everyone is making money, who cares? However, as the competition becomes stiffer and the rapid expansion slows to more moderate levels, this relaxed view towards official corruption will receive more public scrutiny. Foreign investors will also demand more open and honest business practices because their profit margins will not support this additional expense.

Also of great concern is the emerging corruption that organized crime is bringing into the country. Officials told us that the Triads from Hong Kong, along with other organized criminal elements, have been involved in incidents of prostitution, protection rackets, drugs and other illegal activities. These criminal activities were virtually shut down when the Communist Party exerted almost complete control over society. The new economic openness will be an obvious target for officials either against openness, or concerned with the social ills that are reappearing in their society. This aspect has the tendency to work against furthering the capitalistic approach.

**Consumerism**

The most obvious social change apparent to us in our travels was how consumer oriented this supposedly " communist controlled" society has become. One Chinese leader expressed concern over the downward trend of China's historically high personal savings rate, especially in the younger generation. With increasing opportunities for higher incomes, the Chinese people (at least in the urban areas we saw) are creating one of the world's great marketplaces for consumer goods. Shanghai's Nanjing street had kilometers of brightly lit shops that seemed to rival 5th Avenue. This is in marked contrast to what we were told existed just two or three years ago. Then these cities had just a small number of state controlled shops

with limited commercial products for sale.

To us, the most telling signs of progressive change in China's society were the abundance of TV antennas and satellite dishes covering the rapidly erected housing, and the predominance of western dress. The drab, blue, unisex Mao jackets are only seen on a few older people. Ordinary Chinese now wear brighter colored fashions, sporty suits, and miniskirts!

**Religion**

Although we didn't observe much religious activity during the trip, we were told that religious tolerance is increasing. This liberalization has been spotty, with some areas (primarily large urban centers) showing more acceptance than others. We did see a few structures where the traditional symbol of Christianity, the "cross," was atop a building. This obvious display of religion seemed remarkable to us in light of previous Communist constraints against practicing any form of religion. This social aspect is another expression of the new "openness" of China.

## RECOMMENDATIONS

The following recommendations are based on our coursework and discussion during the semester and on our observations resulting from our two weeks in China.

### Develop A Comprehensive China Policy

Overall the U.S. needs to develop a comprehensive China policy. This policy should address military relations, MFN status, and U.S. investment in China. East Asian problems don't seem to concern Americans -- we continue to be Euro-centric in outlook. America needs to pay more attention toward our trading problems with Asia and focus more on where our relationship with China will be in the next decade. China sends thousands of its brightest people to the U.S. to be educated every year. Large numbers of younger Chinese will continue to be curious about the democratic process, hence we can influence China's future leaders today!

More specifically, U.S. military presence in the Asia/Pacific region is necessary to protect American economic ties with the countries there. Admiral Larson, CINCPAC, has said, "some 2.5 Million American jobs and $320 billion in direct trade depend on a peaceful Asia/Pacific." By virtue of geography and history, the U.S. is a pacific power with enduring economic, political, and security interests in the region.

### Reestablish Military Relations

Next, we need to re-establish our military relations with China. High-level military personnel exchanges, professional military education, and port visits by U.S. navy ships will open the door to better understanding between each nations military. A better understanding of democratic values by Chinese military leaders will benefit U.S. interests in the region as the Chinese government continues to evolve.

### Support Unconditional MFN

Unconditional MFN is our next major policy recommendation. This provides an opportunity for further economic development and open dialogue between the U.S. and China. Tying MFN to a wide variety of unrelated issues -- human rights, weapons proliferation, and protectionism -- is a "dumb bomb" approach. We should instead use "smart bomb" tactics to solve these issues individually. To do otherwise runs the risk of economic retaliation.

### Promote U.S. Investment in China

Finally, the U.S. needs to board the Beijing express now! By promoting closer military and economic ties to China, the U.S. will find the political issues between the nations easier to balance. Attitudes in China toward the west are improving, albeit at a slower pace than impatient China watchers may desire.

With or without us, the eastern coastal provincial economies will grow with international investments; overseas Chinese will continue to influence their homeland; and western technologies will be sought. China will become a great regional economic power.

**Remain Cooperatively Engaged**

The key criterion for successful Sino-U.S. relations is for us to remain cooperatively engaged with the ancient middle kingdom. We must create an environment for continued U.S. economic growth to promote democracy and to support regional security. In the final analysis, the best approach to dealing with China's continuing growth in both economic and military arenas is to engage Beijing in a dialogue aimed at fostering cooperation.

In closing, all participants of the 1993 China Survey Trip are unanimous in saying that the trip was a high point of our ICAF year and a significant lifetime experience. We recognize that NDU and the U.S. government expended extensive resources to plan, coordinate, and execute this trip. Unquestionably, we feel that the benefits gained outweigh the expenditures. All participants acquired a better understanding and new perspectives about China, the Asia/Pacific region, and corresponding U.S. regional roles. We hope this report provides timely and useful information about China and its relationships to the U.S.